JOURNAL

VOLUME 13, NUMBER 8 • AUGUST, 1957

AST ENGINEERING
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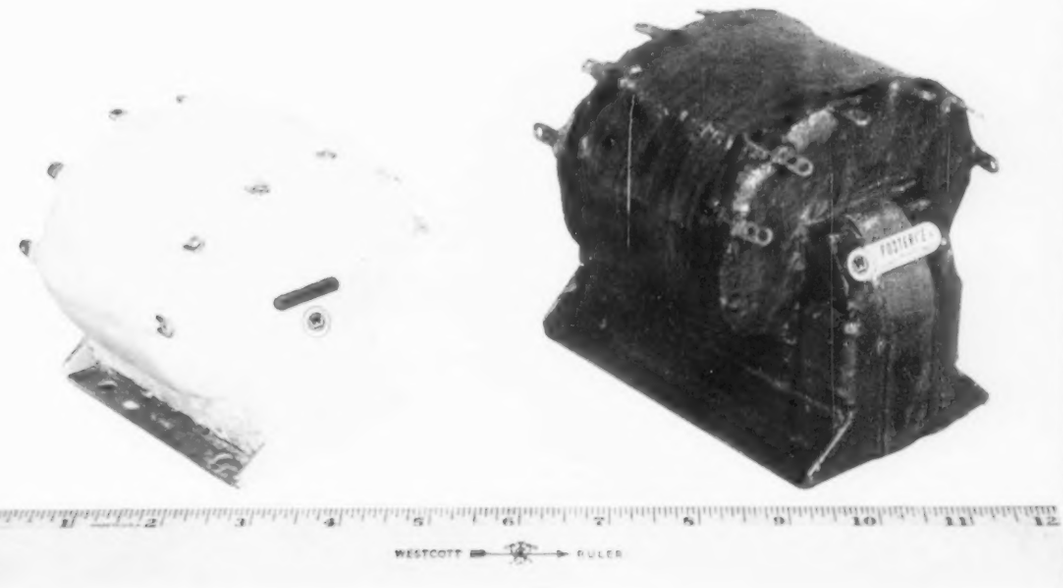
Silicones Provide Insulation for Miniature Power Transformers



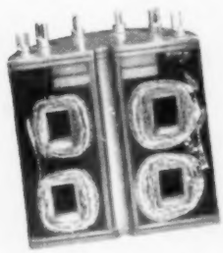
PUBLISHED BY THE SOCIETY OF PLASTICS ENGINEERS, INC.

Miniature electronic components potted in Epon resin by Freed Transformer Company, Inc., Brooklyn, New York

Why **EPON**® **RESINS** for potting?

4 Good Reasons!

1. Outstanding adhesion to metal, glass, plastics
2. Excellent dimensional stability
3. High mechanical strength
4. Excellent dielectric properties



Section of magnetic amplifier coils embedded in Epon resin by Westinghouse Electric Corporation, Pittsburgh, Pa.

EPON RESINS are preferred for potting, laminating, sealing and encapsulating because they offer an almost ideal combination of electrical and physical properties.

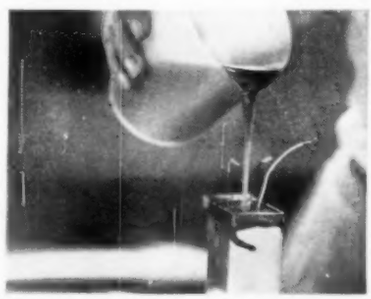
Potting and encapsulating. Epon resins have outstanding adhesive properties. They form strong bonds to metal and glass, provide airtight enclosure of delicate components and vacuum tubes. They also have excellent dimensional stability and can withstand solder bath temperatures.

Sealing. Enamels and varnishes based on Epon resins provide excellent moisture sealing plus outstanding resistance to solvents and chemicals, even at elevated temperatures.

Laminating. Epon resins, laid up with inert fibrous fillers, produce base laminates of superior dielectric properties which can be sheared, punched, drilled and bath soldered.

Adhesives. Solvent-free Epon resin formulations cure at room temperature, with contact pressure alone; form powerful bonds between glass, metal, wood or plastic.

Write for complete information on the use of Epon resins in protective enamels, tool and die materials, etched circuit laminates, transformer and motor sealing compounds.



Potting transformer with Epon resin at PCA Electronics, Inc., Santa Monica, Calif.

SHELL CHEMICAL CORPORATION

CHEMICAL SALES DIVISION 380 Madison Avenue, New York 17, New York

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SHELL

Film of **TENITE POLYETHYLENE** helps "package" many items

ENGINEERING LIBRARY

Here's an ingenious use illustrating three properties of polyethylene that make it a valuable packaging material.

The young lady in the picture has solved the perennial vacation problem of how to keep household plants growing while the family's away. Her solution is to "package" them in bags or film made of Tenite Polyethylene.

The polyethylene, offering resistance to transmission of water vapor, insures that water will not escape. However, the polyethylene film is gas permeable, transmits oxygen and carbon dioxide, and permits the plant to "breathe." Finally, being transparent, the film lets the sunlight through.

Transparency, gas permeability and water resistance are important in many packaging applications. But Tenite Polyethylene offers still more advantages. It is heat sealable... chemically inert... doesn't puncture, tear or "run" easily... remains flexible at low temperatures. Small wonder, then, so many of the things we buy now come packaged in Tenite Polyethylene.

Many industries are finding jobs for this versatile Eastman plastic. Adapted to rapid injection molding or continuous extrusion, Tenite Polyethylene is being used as wire and cable covering... industrial tape... coatings for paper, film and foil... containers of all types ... pipe... housewares and other molded products. For more information on its properties and uses, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
POLYETHYLENE
an Eastman plastic

1932 – EASTMAN'S 25TH YEAR IN PLASTICS – 1957

POLYETHYLENE PROCESSING TIPS

Vol. II, No. 4

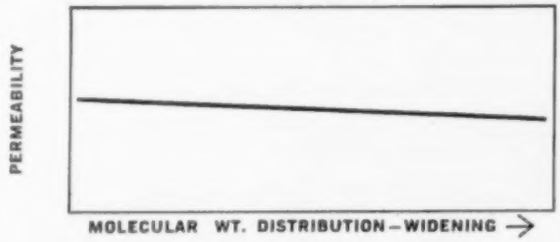
HOW MOLECULAR WEIGHT DISTRIBUTION AFFECTS POLYETHYLENE PROPERTIES

MOLECULAR WEIGHT DISTRIBUTION is one of three basic characteristics that determine the properties of articles made of polyethylene. MOLECULAR WEIGHT and DENSITY are two others.

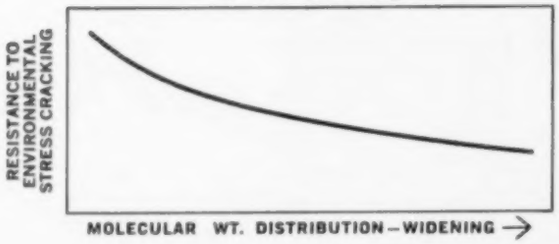
Any polyethylene resin contains molecules of many different sizes. Molecular weight distribution is a measure of how widely these sizes vary from the average.

The following graphs show the effects of widening MWD, assuming density and molecular weight remain unchanged. In aiming for specific end properties, of course, all three characteristics must be taken into account, as all can be varied.

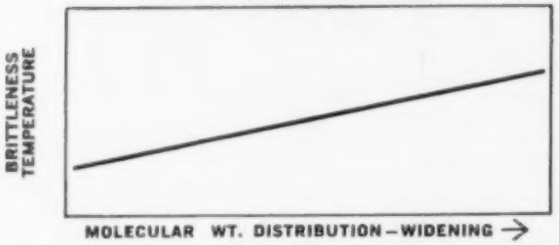
Permeability



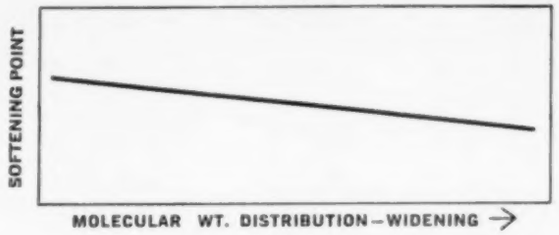
Resistance to Environmental Stress Cracking



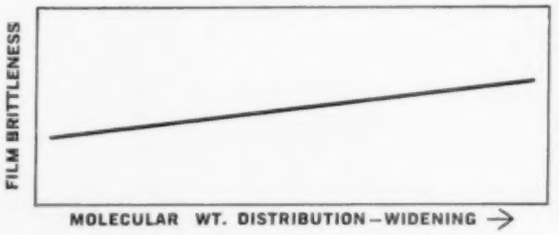
Low Temperature Brittleness



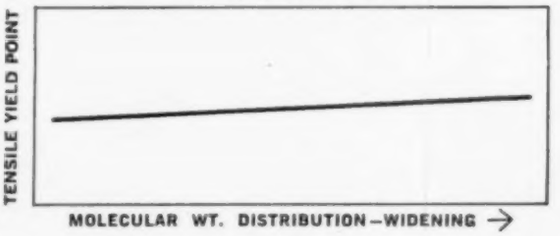
Softening Point



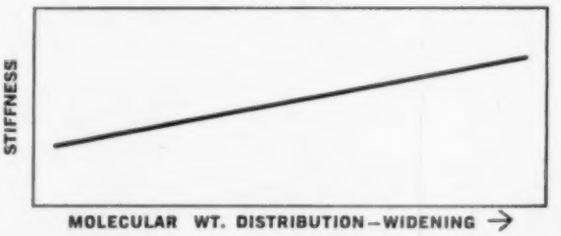
Film Brittleness



Tensile Yield Point



Stiffness



U.S.I. "Tips" covering the effects of density, molecular weight and molecular weight distribution have now appeared, and make a handy reference guide. To receive copies, just ask for back issues of "Polyethylene Processing Tips."

If you're planning a new or improved polyethylene product remember that U.S.I. PETROTHENE® resins have been tailored to give you the properties you want.

Why not call in a U.S.I. technical service engineer ...and talk over your project with him.

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SPE JOURNAL

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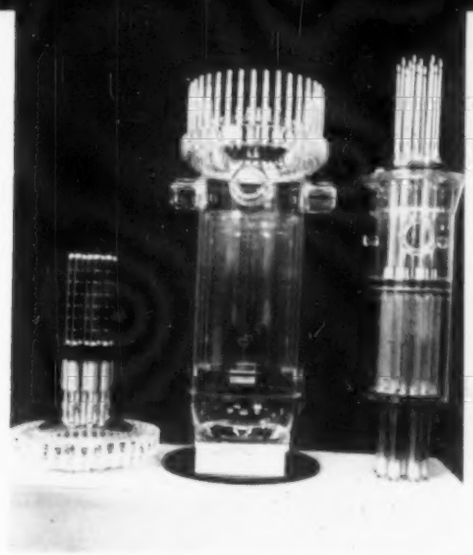

This model of the 11,500-kw Belgian Thermal Reactor, which is being built by Westinghouse Electric Corporation, is about four feet high and is made to an approximate one-sixth scale. All moving parts of the model, which is made of 512 colored plastic parts, correspond to the moving parts of the actual reactor.

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Improved-quality extrusions at faster rates with

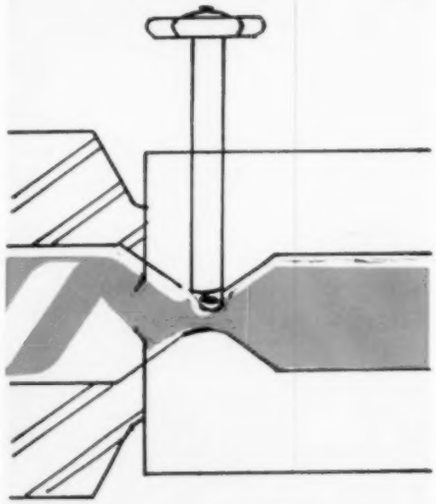
new "controlled pressure" extrusion technique

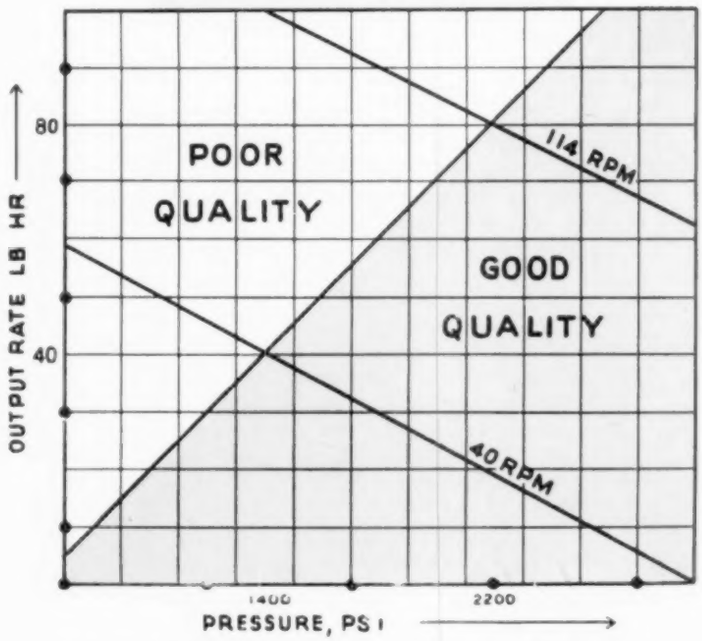
Experiments have shown that extrusion quality is related to three primary factors—pressure, resin temperature, and extrusion rate. A change in any one of these factors affects one or both of the others.

Now, Bakelite Company Laboratories have developed an efficient, accurate method of controlling pressure during the extrusion operation. Essentially, it employs a valve between the extruder head and the die, together with a pressure gauge and an immersion thermocouple in the head, or between the head and the valve.

This process provides a continuous method of control. Proper manipulation of pressure and screw speed results in better temperature control and improved resin homogeneity, better mixing characteristics and an improved product at increased output.

The development of this controlled-pressure (valve) extrusion by Bakelite Company permits operation of all extruders at their maximum capacity while maintaining highest quality.





The above graph on a typical sample run gives dramatic evidence of the effect of the controlled pressure (valve) extrusion technique on output. Without the valve, the highest usable screw speed, giving commercially acceptable quality, was 40 rpm. This resulted in an output rate of 40 pounds per hour or 100 feet per minute (Point A) When the streamlined controlled pressure valve was used, the screw speed could be increased to 114 rpm, *DOUBLING* the acceptable-quality production rate (Point B).

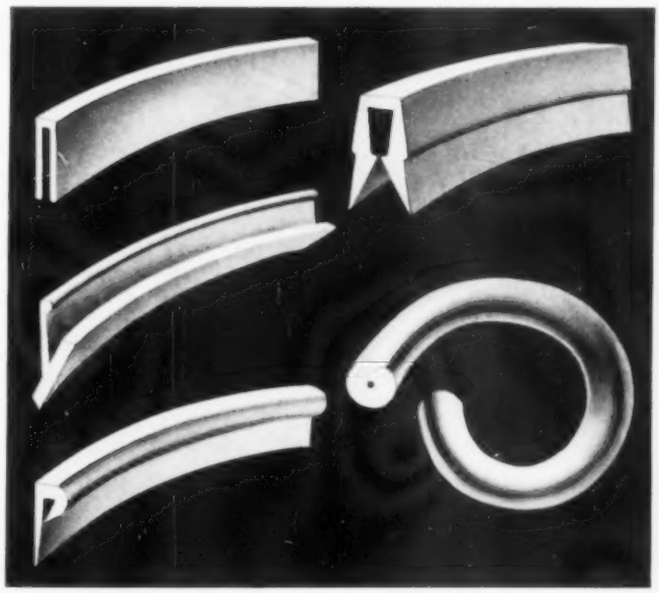
The values used in the above figure are the result of one sample test run under a typical set of extrusion conditions and should not be applied empirically to other extrusion conditions. Conditions used in this test were as follows: two inch extruder using a dry blend electrical compound based on QYRS extruded on number 14 wire with a wall thickness of 1/32 inch. Improved extrusion results, similar to those shown for wire and cable, may be expected for other applications.

new BAKELITE BRAND dry-blend Vinyl Resin QYRS

Controlled pressure (valve) extrusion permits the extrusion of dry-blend resin comparable in quality to the extrusion of hot-flux materials. When used with BAKELITE Brand Vinyl QYRS, it results in a superior product with improved finish, reduced roughness, and minimum "fisheyes".

Advantages of QYRS include the following:

High bulk density of 30-35 lbs./sq. ft., permitting larger tonnage output rates from a given size blender.



QYRS is desirable for preblend formulations used in both electrical and non-electrical applications. It is particularly suitable for building wire, flexible cord, appliance wire, telephone wire, power cable, and such contour extruded items as garden hose, welting, and belting.

High specific viscosity of 0.205 to 0.220, resulting in improved physical properties, such as strength.

More uniform particle size, ensuring maximum extrusion rate, minimum dusting, and proper dispersion of plasticizer with resin.

Batch-to-batch uniformity, assuring uniform extrusions.

Faster dry blending time, based on tests that prove QYRS will dry blend 10-15% faster than conventional resins while still maintaining excellent dispersion of ingredients.

Utilization of present cycle, so that fabricators can use the same blending cycle as presently employed with other dry-blending resins.

Adaptability to a shorter cycle as a result of faster plasticizer absorption.

For further information on the controlled pressure (valve) extrusion method and the new BAKELITE Brand dry-blend vinyl resin QYRS, write Dept. YZ-171

BAKELITE
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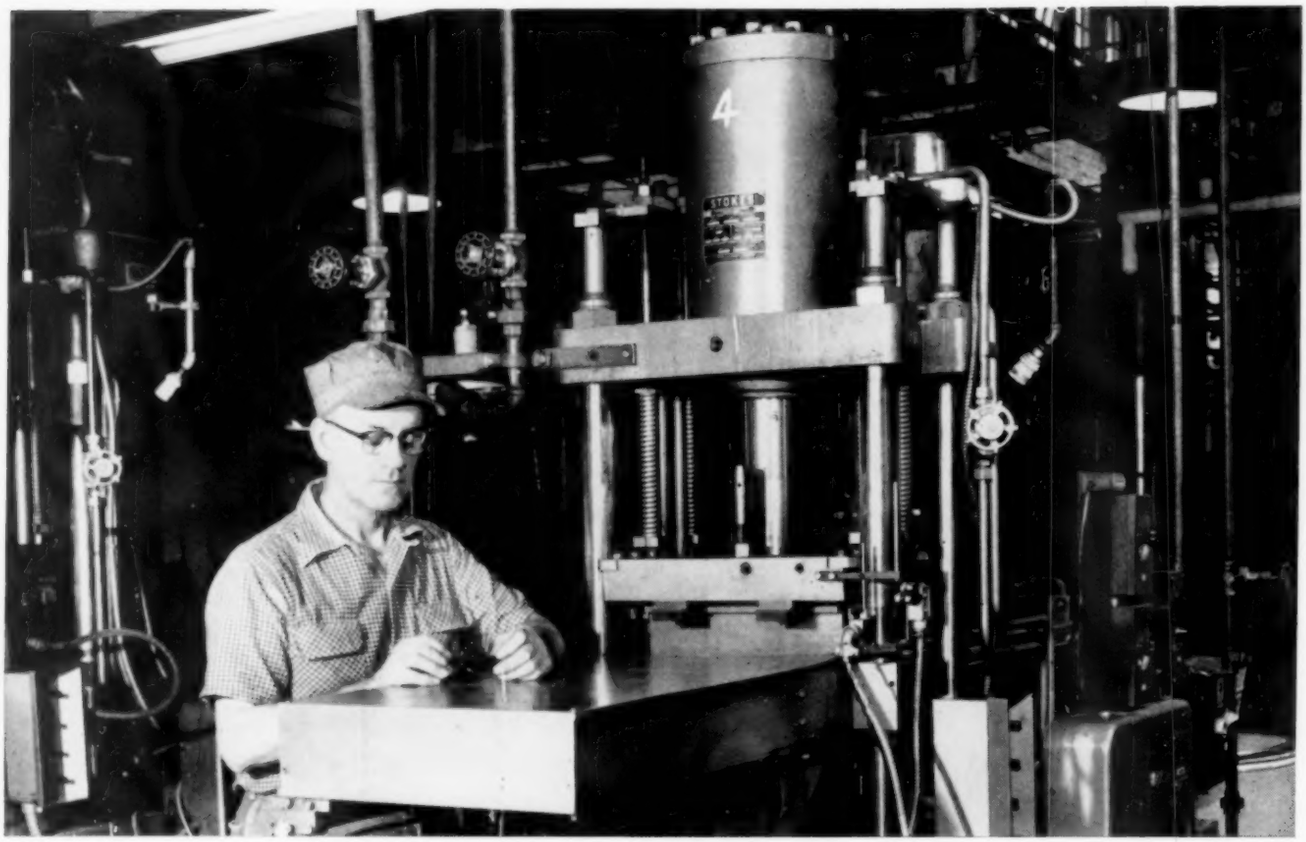

American Insulator Corp. uses Stokes automatics for flexible custom molding...

A bank of Stokes Model 741 fully automatic compression molding presses is being used to mold a wide variety of precision electrical insulating parts at the American Insulator Corp., New Freedom, Pa.

The company, one of the foremost custom molders of plastic products, produces parts ranging from small electrical plugs to jet tappets for steel mill use. American Insulator uses these Stokes automatic high speed molding presses for fully automatic, around-the-clock operation.

The complete flexibility and ease of adaptation and changeover of the Stokes 741's enables American Insulator to bid successfully on an infinite variety of jobs—and to meet all customer specifications. Continuous research and development has helped this company to achieve and retain a recognized leadership in their field—enables them to service the most difficult jobs.

Built into these 741's are refinements that Stokes has developed during 25 years of leadership in automatic molding:

Positive top knock-out—an exclusive Stokes feature.

No mold damage—from parts falling back in the die.

Simplified feed set-up—changeovers take only 5 minutes.

Fastest press cycles—8 seconds dry cycle time is 40% faster than any comparable machine.

Space-saving design—cuts costly floor area requirements.

Tops in versatility—handles greatest variety of parts and materials.

Stock die sets—are designed to 741 specifications.

Capacities of 50, 75, 125 and 200 tons are available. Write for our latest bulletin, and for a consultation on your molding problem.

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F. J. STOKES CORPORATION
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STOKES

Thin wall clear polystyrene containers are formed in this mold of CRUCIBLE CSM 2. Mold Builder: Standard Tool Company, Leominster, Mass.

they picked ultrasonically inspected

CRUCIBLE CSM 2

from warehouse stocks

FOR HIGHER FINISH . . . LONGER MOLD LIFE – It takes a highly polished and dimensionally accurate mold to form clear styrene into these thin walled containers. And, because production-runs go into the millions, the mold steel has to be long lasting. Both are good reasons why CRUCIBLE CSM 2 was selected.

For CRUCIBLE CSM 2 is an exceptionally *clean* steel—uniform in composition and structure—with superior machining and polishing characteristics. And for absolute dependability, *every piece* of CSM 2 is ultrasonically inspected.

What's more, for your convenience, CSM 2 is immediately available from Crucible *warehouse stock* in 205 sizes. Next time you need mold steel—call Crucible. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

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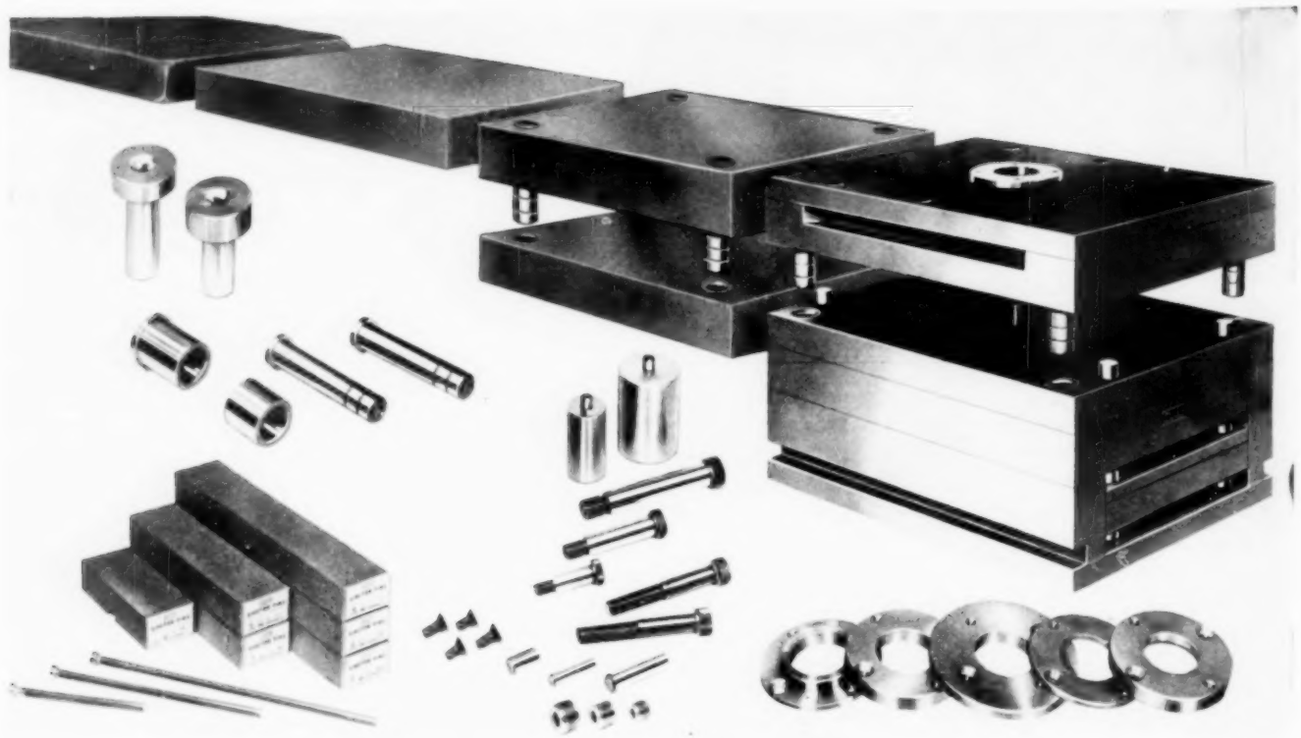

PROGRESS THROUGH STANDARDS

. . . and how DME "helped"

The history of economy in modern business has been directly related to the history of Standardization. One of the major elements affecting the economic production of finished plastic parts is the high initial cost of the mold. A progressive step in reducing mold cost, without sacrificing the high quality required, has been successfully achieved through Standardization.

When D-M-E originated Standard Mold Bases and their component parts in 1942, it provided the answer to the rapidly growing demand for high quality molds that would maintain and promote the economic advantages of plastic parts.

Through large volume purchases of quality steel in standard sizes and specialized production facilities, D-M-E was able to produce and supply high quality Standard Mold Bases to mold makers and molders at such great savings in cost and time that the benefits of Standardization were quickly realized by the Industry.

Today D-M-E produces twenty-eight different sizes of Standard Mold Bases, from 9" x 8" to 23¾" x 35½", in either D-M-E No. 1 or No. 2 Steel, with a wide range of cavity plate thicknesses to satisfy the diversified demands required. In addition, over 2,000 finished component parts of the same high quality are available to provide additional savings in service as well as in the product.

Properly engineered Standardization puts the accent on Economy. When you "Specify D-M-E . . ." you get Quality, Service AND Economy!

Specify **D-M-E**
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SERVICE . . .
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CORROSIONEERING with LAMINAC®
Polyester Resins

Pulp mill stems corrosion and stock contamination with reinforced PLASTIC

Versatile, reinforced LAMINAC Polyester Resin is solving several corrosion problems for MacMillan & Bloedel, one of Canada's major pulp and paper mills.

In the bleach pulp plant, for example, highly corrosive chlorine dioxide, sulphur dioxide, and chlorine are used in processing. Trouble with leakage plagued stainless steel sewer lines used to remove spent chemicals. Contamination by metal had developed in the conveyor screw handling bleached kraft stock from washer to storage.

Lined 20 months ago with glass-reinforced LAMINAC 4119, the conveyor screw, shown here, is holding up well, no longer contaminates. Now all sewer lines are being lined with LAMINAC, while lines in a new plant under construction are to be entirely fabricated of this material. MacMillan & Bloedel has fabricated a 3-foot reinforced LAMINAC radial exhaust fan, and is covering floors and ceramic and wooden exhaust stacks with reinforced LAMINAC.

You may find reinforced LAMINAC equally versatile for handling corrosive materials, fluid and fumes. Talk with your Cyanamid representative about the many possibilities it offers for reducing maintenance and extending equipment life.

Fibrous glass cloth being applied to flight of conveyor screw which moves bleached kraft stock from washer to storage.

Finish coating of LAMINAC *Resin is applied to conveyor screw with built-up coating of* LAMINAC *and glass cloth.*

Conveyor in operation. Inside of trough, as well as screw, is lined with glass fabric-reinforced LAMINAC *Resin.*

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Pyle-Star-Line Connectors with inserts molded of Resinox 3700 green exceed both military and NEMA requirements. They are compact, light in weight, water-proof, gas-proof, shock-proof, dust-proof.

Resinox 3700

green is the first phenolic type molding material to meet the very exacting Mil-C-5015-B Specifications for connectors. A low water absorption thermosetting material, it has been formulated to meet the critical requirements of ordnance connectors. It offers excellent arc resistance even under the most extreme environmental conditions. Designed for automatic molding, Resinox 3700 green makes possible better connectors at lower unit costs. Its unusual dimensional stability, including less after-shrinkage, plus superior automatic molding performance, means fewer rejects. Components made from this premium grade Monsanto compound possess exceptional electrical properties with improved impact resistance. For complete data on Resinox 3700 (frequently the *only* thermosetting material that can solve a critical electrical problem), write to Monsanto Chemical Company, Plastics Division, Room 1875, Springfield 2, Mass.

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GERING—FIRST CHOICE FOR QUALITY AND CUSTOM TAILORED MOLDING COMPOUNDS

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• Acrylics • Styrene Copolymers • Butyrate

Gering reprocessed thermoplastics can cut your costs—just as it does daily for hundreds of leading molders—by giving you real savings on materials without sacrificing quality! Now, with any given blend, your molding compound is furnished in uniform, dust-free pellets and the blend matches perfectly from first bag to last. That's possible because Gering uses the most modern equipment and methods under an exacting system of quality controls. For more than 30 years this response to customers' individual needs has earned Gering its reputation for top-notch service.

Special offerings of high quality reprocessed thermoplastics are announced through a new bulletin service. We'll be glad to send these money-saving notices to you. Just send us your name.

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Basic non-captive production of National Adipic Acid at Hopewell, Va. gave the rubber, plastics, plasticizer, lubricant and chemical industries a major new source. Outstanding product-quality has made National Aniline the preferred supplier of many substantial users.

If you use or contemplate using this versatile dicarboxylic acid, we urge you to get a working sample, price and delivery quotation on National Adipic Acid. You'll find it sets a new industry standard in every important respect.

WRITE ALSO FOR TECHNICAL BULLETIN I-12

This fact-filled, 8-page bulletin on National Adipic Acid gives complete physical and chemical properties, principal reactions of the carboxyl and alpha methylene groups; solubility curve; suggested uses and copious literature references.

NATIONAL ANILINE DIVISION

ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

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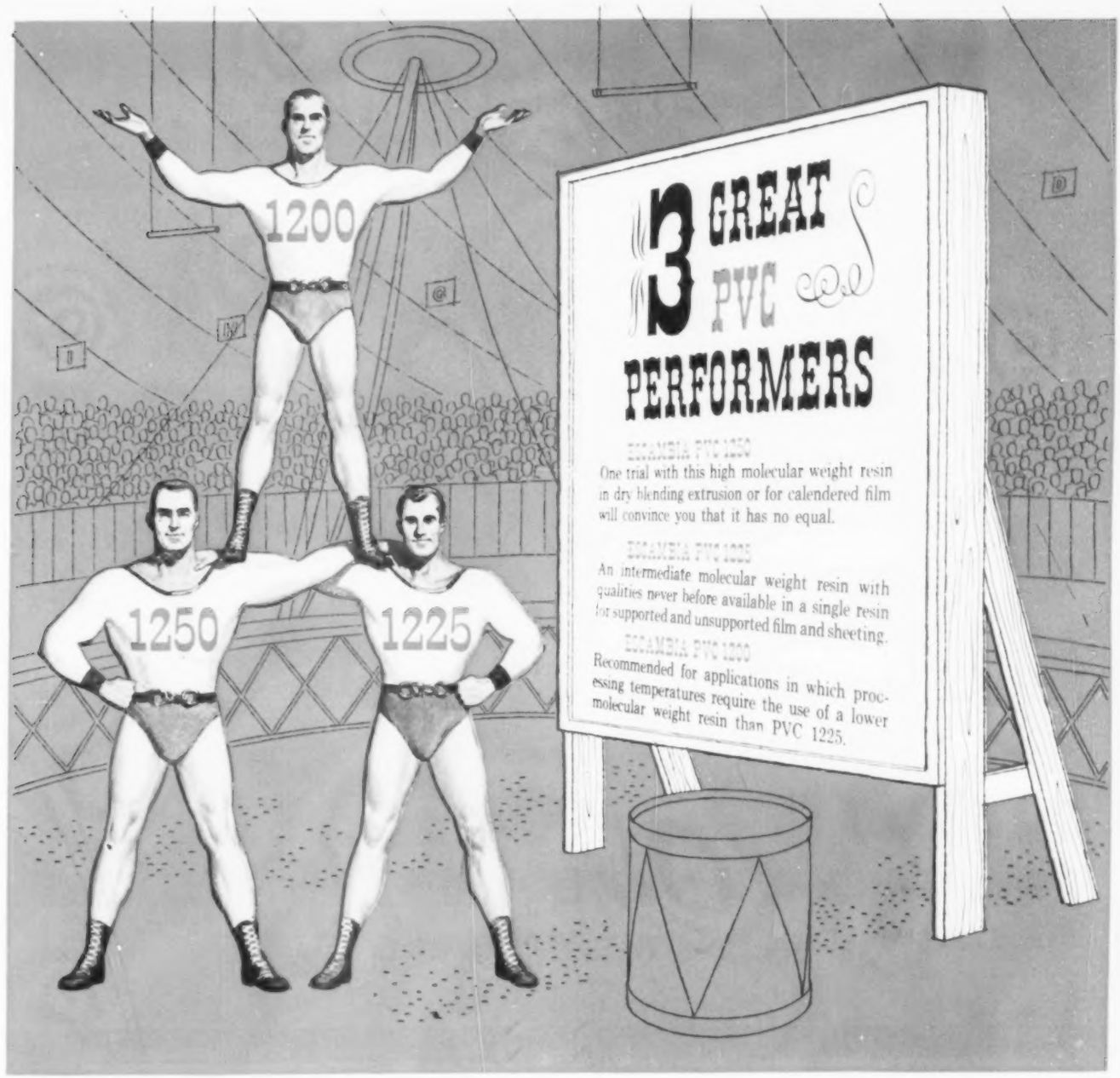
1200
1250
1225
3 GREAT PVC PERFORMERS
One trial with this high molecular weight resin in dry blending extrusion or for calendered film will convince you that it has no equal.
An intermediate molecular weight resin with qualities never before available in a single resin for supported and unsupported film and sheeting.
Recommended for applications in which processing temperatures require the use of a lower molecular weight resin than PVC 1225.

Whether your product calls for high, medium or low molecular weight resins—the outstanding properties of Escambia's series of Straight PVC resins will save you processing time and costs:

- Outstanding Heat Stability
- Free-Flowing Hot Pre-Mixes
- Very Low "Fish Eye" Count
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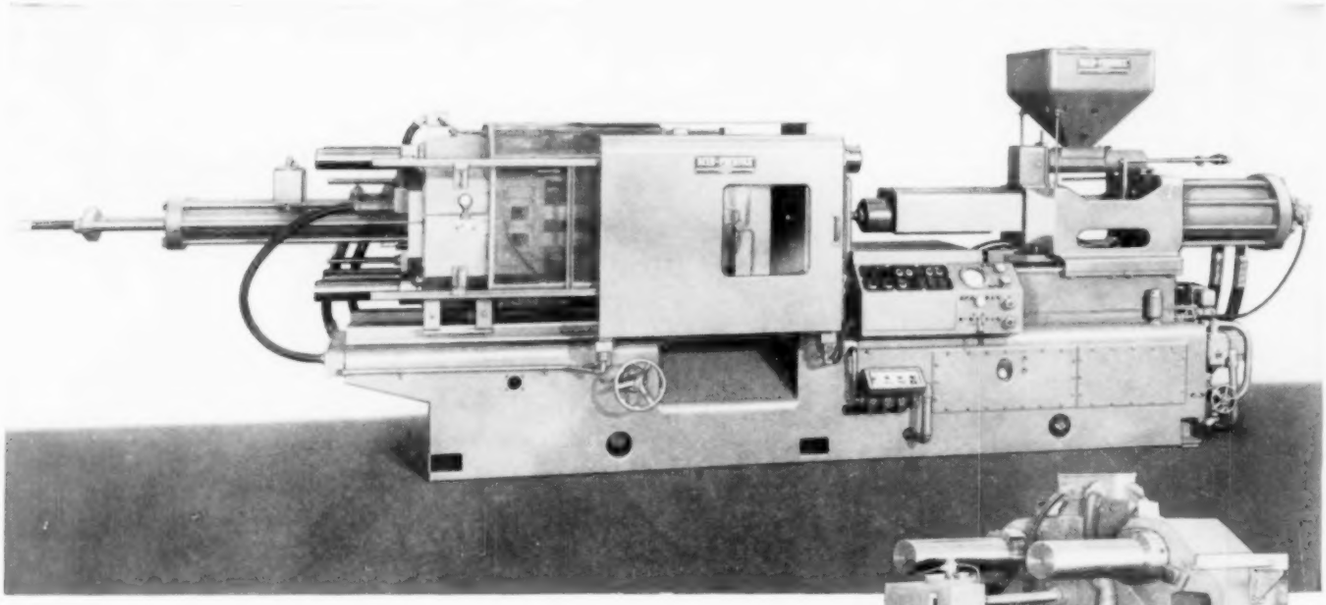

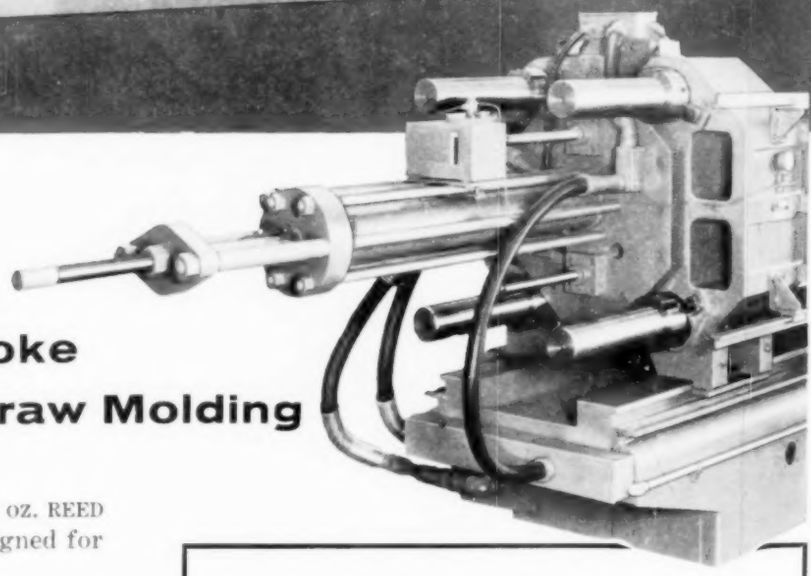

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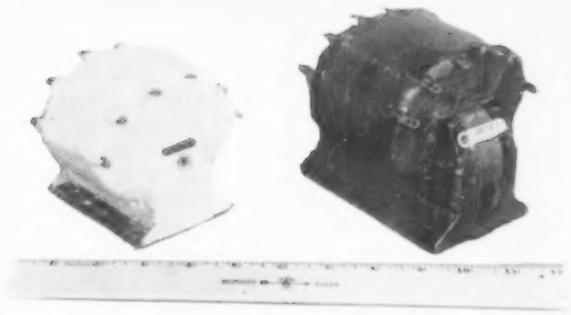

Silicon Polymers As High-Temperature Insulation for Miniature Power Transformers

F. T. Parr
Westinghouse Electric Corporation
Baltimore, Maryland

. . . organosilicon materials are the answer to special high temperature electrical insulation requirements . . .

Insulation of some sort is absolutely essential to every electric circuit and electrical device. For some applications inexpensive, easy-to-apply insulation may be very satisfactory. For other applications, especially those wherein the insulation will be exposed to temperatures in the range of 160°C, (Class H) and up, more expensive materials with longer process times may be required.

Since insulation is the keystone to reliability in electric equipment, much thought and effort should go into the design of insulation for a particular component.

In selecting an electrical insulating material, we must consider its effectiveness as an insulator, dielectric constant which is a measure of the insulator's capacitance as compared to the capacitance of air, power factor which is the dielectric loss of the insulation acting as a capacitor, dissipation factor which is analogous to power factor, and dielectric loss which is the product of its dielectric constant and the dissipation factor. All of these values are determined at a specific temperature, humidity, degree of cleanliness, level of applied test voltage and time. When these values are obtained, a particular material may more reliably be selected as an insulating system.

This paper will be limited to a discussion of the use of organosilicon compounds for insulating miniature power transformers for high temperature operation. Power transformers are different from other transformers in that they generate a large amount of heat during operation and when they are miniaturized, a heat problem exists.

The high temperature referred to is a minimum of 200°C up to 275°C hot spot or winding temperature for a minimum of 500 hours, with the hot spot being the area in the windings of a transformer wherein the greatest amount of heat is liberated during its operation cycle. This temperature has been determined by embedding thermocouples in test transformers. The environmental or ambient temperature at the same time may be from 160°C to 200°C. These temperatures are beyond the limitations of transformers with the conventional organic Class B and Class A insulating materials, hence a more temperature resistant material is necessary for operation at these temperatures.

The evolution of faster flight with the subsequent rise in frictional heat caused by the air resisting the object in flight, coupled with the greater heat generation brought about by faster operation of the electrical control system of a plane or missile, brings about a substantial rise in total heat present in and around the operating electrical equipment.

One solution to the heat problem would be to provide a refrigeration plant to cool the equipment. A more practical solution is to build equipment capable of operating at higher temperatures. This can be accomplished by using

This paper was presented at the 130th National Meeting of the American Chemical Society.

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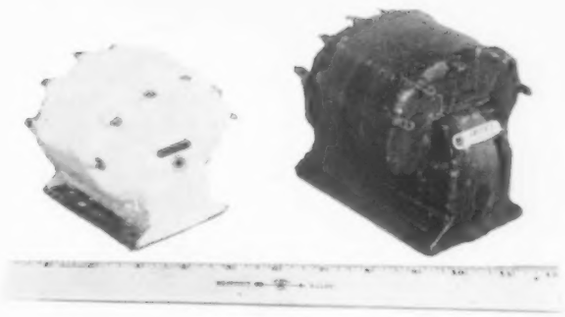

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Table I

Physical Properties of Solventless Silicone Rubber

Color	White
Tensile Strength	400 psi
*Elongation	150%
*Thermal Conductivity	0.55 X 10 cal/gram/sec cm²-deg C/cm
*Volume Resistivity	17.2 X 10¹⁵ ohm/cm
*Dielectric Strength	500 volts/mil.
Life Test 250°C	Min. 4 wks.
Life Test 200°C	Min. 60 days.

**Tests run using standard A.S.T.M. Method.*

heat resistant organosilicon compounds in place of the conventional organics as insulating materials for this equipment. One of the advantages gained by using the organosilicon compounds for insulation in transformers specifically is that a smaller magnet wire can be used in winding the coils of the transformer. A greater heat loss occurs through a smaller wire during operation of the transformer, but the organosilicon insulation can withstand this heat without deterioration. The advantage of the smaller wire is reduction in size with a corresponding weight reduction but with a functionality identical to the larger heavier transformer. This reduction in weight and size is very desirable in airborne electrical equipment. The photo in the title of this paper shows a comparison between a standard miniature transformer, and the same unit constructed and insulated for high temperature operation. There is about a 50 percent reduction in size, hence a corresponding weight reduction.

Materials of Construction

The high temperature transformers referred to in this paper operate on 400 cycles. The materials of construction of these transformers are Quinterra coil form, and Quinterra sheet asbestos inner layer insulation. The terminal boards are silicone glass laminate. The tapes used are woven glass, and a woven glass tape impregnated with a silicone rubber with a pressure sensitive adhesive applied to the back of the tape. The magnet wire is copper coated with a silicone modified polyester-amide enamel. The leads are soldered to the terminals of the transformers using a high temperature solder. The core of the transformer is silicon steel and the mounting bracket is stainless steel.

Materials for Treatment

The encapsulating or outercoating material for the transformer is a blend of a high and a low viscosity silicone rubber. The blending is necessary in order to get a viscosity low enough for dipping. This silicone rubber is prepared by milling together a dimethyl silicone polymer, an inorganic filler such as silica and a vulcanizer. This rubber, which is available on the open market, is solventless as applied. Upon casual inspection, it is difficult to distinguish between organic and silicone rubbers. The simplest way to identify them is to burn a sample of each one. Organic burns with a black sooty flame and leaves a small amount of residue, while silicone rubber burns with a white smoky flame leaving about 90 percent residue. Also, the physical and electrical properties of silicone rubber are very good at both elevated and low temperatures. The organic rubbers, however, are not as good at elevated temperatures.

Physical Properties

A list of some of the physical properties of the solventless silicone rubber used to encapsulate the transformer is given in Table I.

The lower tensile strength of the silicone rubber as compared to organic rubbers is offset by the excellence of its other properties.

Another material used in the treating process is a silicone varnish composed of a methyl phenyl substituted siloxane polymer dispersed in 50 percent xylene. This varnish is used to bond together the asbestos packing material which is used to cover the two open faces of the transformer to be encapsulated.

A third material, tetra-N-butyl titanate, in anhydrous hexane is used as a primer to promote better adhesion between dissimilar materials, in particular, the metal parts of the transformer and the silicone rubber.

The reaction which the primer undergoes proceeds as follows: the solvent evaporates leaving the butylester which is hydrolyzed by atmospheric moisture to form a hydroxyester which further reacts with more moisture to form an alcohol and a thin clear amorphous birefringent film of titanium dioxide. The alcohol formed evaporates leaving the film which promotes adhesion to the treated surface.

Table II

Physical and Electrical Properties of Solventless Silicone Impregnating Resin

Tests	Values	Tests	Values
Color	White to slightly yellow	Dielectric constant*:	
Shrinkage	5.7% by volume	at 25°C, 60 cps	2.80
Weight loss at 200°C after 30 days	2.94%	at 150°C, 60 cps	2.57
		at 25°C, 1 kc	2.79
Hardness (Shore Durometer "D")	81	at 150°C, 1 kc	2.54
		Power factor*:	
Heat Distortion using 10 mil defl. + 264-lb load*	73°C	at 25°C, 60 cps	0.07
		at 150°C, 60 cps	0.28
Water absorption*:		at 25°C, 1 kc	0.16
in 24 hours	0.028%	at 150°C, 1 kc	0.16
in 30 days	0.038%	Dielectric strength*:	
Thermal conductivity*	0.00345 watts/inch/inch squared/°C.	at 25°C,	650 V/M
		at 250°C	250 V/M
		Volume resistivity*	
		at 25°C,	above 10¹⁵ ohms/inch
		at 250°C	above 10¹⁵ ohms/inch

**Tests run using standard A.S.T.M. Method*

Solventless Silicone

The fourth material used, and perhaps the most unique, is the solventless silicone impregnating resin.

The solventless resin is an improvement over the solvent-containing type of organosilicon impregnating varnishes for Class H insulation which have been available for a number of years. The disadvantage of the solvent-containing type is that during cure of the resin it is necessary to drive off the solvent present. The evaporation of the solvent reduces the volume of the impregnant and thus presents the possibility of voids being left in the impregnated unit. This is highly undesirable in high-voltage transformers, because of corona problems, hence a solventless impregnant was sought.

The biggest obstacle to surmount in synthesizing the solventless resin was that of providing a highly reactive low-viscosity silicone resin which would thermoset to a solid mass. These requirements were met by synthesizing a silicone polymer which depends upon vinyl groups attached to silicon for final cure. The solventless resin has a viscosity of 380 cps. at room temperature, and is thus very satisfactory for impregnation use.

The requirements of a resin that is to be used for impregnation are quite rigorous. Besides being thermally stable, such a resin should have a viscosity low enough to penetrate the interstices of the solid insulation in a short time. It must further have a long shelf life, yet thermoset in the equipment in a reasonable time and at a convenient temperature. The resulting solid must set to a tough solid with no cracks or voids.

Several catalysts were evaluated with this resin combination, with ditertiary butyl peroxide giving the best all around results.

The reaction which the catalyzed resin undergoes is a cross-linking addition polymerization, hence no by-products are given off during the polymerization and cure. The resin is 100 percent reactive.

A list of the physical and electrical properties of the solventless silicone resin catalyzed with ditertiary butyl peroxide are as given in Table II.

The shelf life of the catalyzed resin at room temperature is in excess of one year. This is a big advantage for impregnation work.

Treatment of the Transformers

Prior to complete assembly the terminal boards are given a dip coat of the silicone rubber that is used for encapsulation. The rubber is partially vulcanized, and then the terminal boards are assembled into the units, and pretested electrically for continuity, insulation resistance and turns ratio.

Figure 1 shows an assembled transformer. This unit is packed on the open faces with a paste made from asbestos fibers wetted with silicone varnish. A $\frac{1}{8}$ inch thick Teflon strip, $\frac{1}{4}$ inch wide is packed against the open faces leading from the core to the top of the unit. This strip when removed later on will leave a channel through which impregnation of the transformer will take place (Figure 2).

The packed unit is placed in an oven at 110°C for one hour to volatilize the xylene solvent in the varnish, then five hours at 200°C to cure the phenyl-methyl type silicone resin. On cooling, the terminals and other metal parts of the transformer are solvent cleaned to remove any grease or foreign matter. A primer, tetra-N-butyl titanate in anhydrous hexane is applied to the metal parts, and the unit is allowed to sit to allow hydrolysis of the ester to TiO_2 to take place. This TiO_2 film promotes adhesion between the metal parts and the silicone rubber next applied.

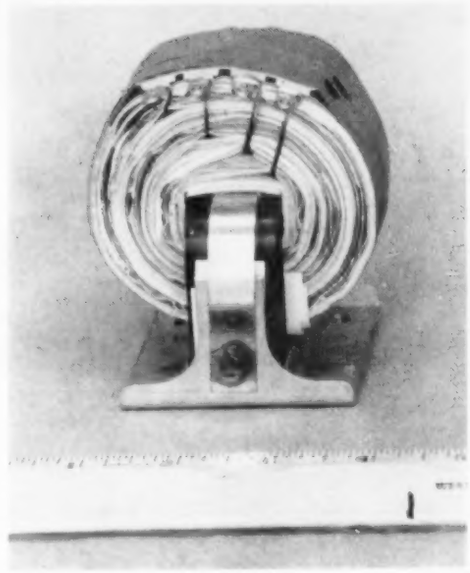

Figure 1

Part prior to impregnation

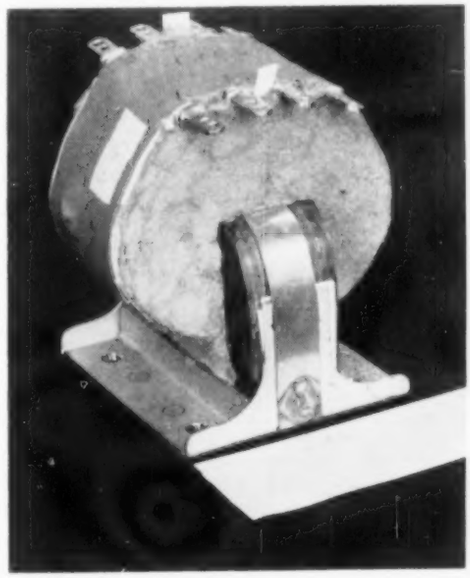

Figure 2

Impregnated transformer

Impregnation

The transformer is then immersed in the silicone rubber mixture, removed, drained in a 60°C oven then placed in a 160°C oven to vulcanize partially the rubber coating. A second coat is applied and cured in a like manner to the cool transformer. After the second coat the Teflon plugs are pulled out of the rubber coated packing and the 60°C preheated unit is then placed in a heated vacuum chamber and a vacuum of 5mm. is drawn for 15 minutes. After this period of time without breaking the vacuum, the pre-evacuated resin is pulled into the chamber, and the vacuum of 5mm. is maintained for 15 minutes. At the end of this period the chamber is returned to standard pressure for 15 minutes. A second vacuum is drawn for 30 minutes, then broken for 30 minutes. The transformer is removed from the chamber and the excess resin is allowed to drain off. The unit is then placed in an oven for partial curing of the resin. After the curing cycle is complete, the unit is removed, cooled, and the surface wiped with a solvent to remove any residual impregnant. Then a third dip coat of the silicone rubber is applied. This coat is cured, in the same

Figure 3

Part after 1000 hour heat test.

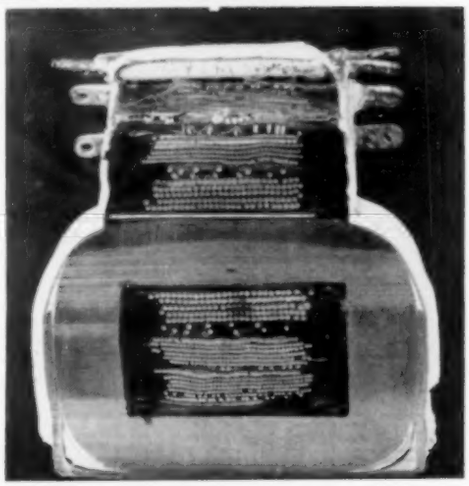

Figure 4

Cross-section of heat-tested part.

Table III

Environmental Tests of Group I Units (Heat Aged)

Test	Average Insulation Resistance Value (Megohms)
Thermal shock: at +85°C	125,000
(3 cycles) at −55°C	200,000
Humidity: 10 days at 98% relative humidity	750
5 more days at 98% relative humidity	200
Salt spray: 50 hours	200

Table IV

Environmental Tests of Group II Units (Not Heat Aged)

Test	Average Insulation Resistance Value (Megohms)
Thermal shock: at +85°C	400
(3 cycles) at −55°C	150
Humidity: 10 days at 98% relative humidity	20,000
5 more days at 98% relative humidity	150,000
Salt spray: 50 hours	30,000

manner as the other two. The unit is then placed in a 200°C oven to bring about a complete cure of the silicone rubber and resin.

This treatment process produces a completely impregnated, void free transformer encapsulated with approximately a 1/16 inch thick layer of silicone rubber.

Test Results

Several groups of transformers manufactured according to this process have been run through a number of environmental and life tests in accordance with military specifications.

One group of transformers was run through tests in the following order: heat aging, thermal shock, humidity, and salt spray. The first test, heat aging, was conducted by placing the units in an oven in an ambient temperature of 160°C, and applying a load (that is, operating the transformer) for 500 continuous hours.

The winding temperatures ranged from 200°C to 250°C during these 500 hours. The result was that no visual defects were observed in any of the transformers.

After the heat aging, these units were subjected to a number of other environmental tests. A list of the tests run with the average results obtained are given in Table III.

A second group of units **not heat aged** were run through tests with the results listed in Table IV.

These same units were then heat aged for 500 hours in a manner similar to Group I units, and no cracks occurred in the outercoat, and no electrical failures were detected.

All of the units were subjected to a 1500 volt overload test and no electrical failures occurred. Values of 100 megohms in any of the tests run are considered good.

Further Tests

The results obtained from the environmental tests point to the fact that the solventless silicone rubber and solventless silicone resin provide an excellent combination for insulating transformers that must operate at high temperatures. A large number of transformers are presently going through all of the tests described earlier plus a number of other operating tests. Some units are also being heat aged to complete failure.

Figure 3 shows a transformer which has been tested through 1000 hours of heat aging at a hot spot temperature of 250°C.

Figure 4 shows another 1000 hours heat aged unit which has been cut in half to show appearance of the inside of the unit after the test.

The entire process described in the paper is covered by patent applications which are on file at this time. Other work is presently in progress to improve the process timewise, and to develop materials capable of operating at still higher ambient and winding temperatures. ★ ★

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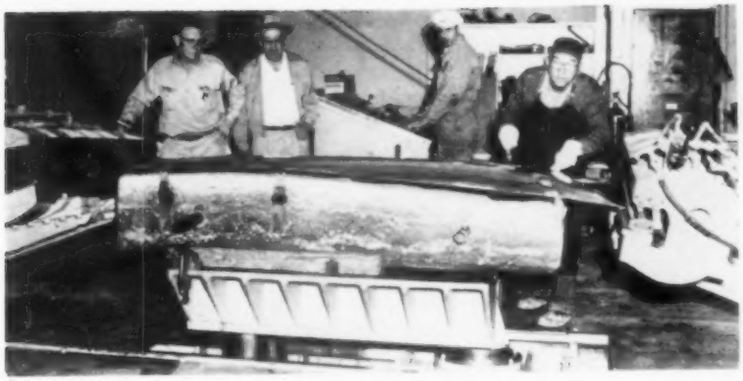


Stretch die of aggregate-epoxy at Douglas Aircraft.

Aggregate Reinforcements for Cast Epoxies

By John Delmonte

Furane Plastics, Inc.
Los Angeles 39, California

THE UNUSUAL BONDING qualities of epoxy resins, coupled with their low shrinkage, has permitted their reinforcement with a large variety of coarse aggregates ranging from smooth glass marbles to well-expanded, edible popcorn. The advantages of some of the coarse aggregate reinforcements have been noteworthy resulting in real economies in the production of cores for large cast epoxy tools. Through judicious balancing of finely divided fillers and the more coarse aggregates, optimum distribution may be achieved, accompanied by good physical properties.

In the interest of clarity, our references to aggregate reinforcements implies coarse, granular particles from ¼ inch mesh size and larger, as distinguished from finely divided fillers. The use of coarse aggregates has been suggested in the manufacture of concrete, combining sand, pebbles and Portland cement. In fact, the manufacture of epoxy tools has gone so far as to utilize the pebble aggregates and sand, replacing the Portland cement with a liquid epoxy resin blended with its curing agent (see photo). A number of tools faced with an epoxy gel coat and backed with sand, gravel and "Epocast" resin formulations have been in service over two years at one of the major aircraft manufacturers. Blending of materials took place in a concrete mixer, and the epoxy concrete mixture was used as a backing for large metal forming tools. The ultimate strengths far exceed those obtained with ordinary concrete utilizing Portland cement. The percentage by weight of activated epoxy resin was in the neighborhood of 9 to 11 percent, sufficient to weld the particles together into a tight mass.

Numerous Materials

There are numerous coarse aggregate materials which may be used with epoxy resins with distinctive results. They include the following:

1. Pebble and stone aggregates such as used in concrete.
2. Silicon carbide or aluminum oxide grains and granules.
3. Silicon dioxide lumps or coarse grains.
4. Porous core volcanic aggregates known as "Epocore."
5. Glass or porcelain marbles.
6. Expanded popcorn.
7. Large aggregates of organic or inorganic origin, preferably which do not absorb the resin binder.
7. Large aggregates of organic or inorganic origin, preferably which do not absorb the resin binder.
8. Expanded micro-balloons.

Rather than review the merits of all of the aggregates listed above, one will be selected which has demonstrated commercial merit and which is currently in wide-scale use throughout the industry as a backing material for large epoxy tools. This aggregate, Number 4 on the list, is "Epocore." It has fulfilled many useful functions. The economics of its application are indicated in Figure 1.

Figure 1.

Density and Cost Factors for One Cubic Foot

Weight of One Cubic Foot	Epocore 50 lbs.	Sand-epoxy 135 lbs.	Cast phenolic 84 lbs.	Cast epoxy 90 lbs.
Cost of One Cubic Foot	$8.00	$15.00	$42.00	$90.00

There are lighter weight materials for filling large voids, though their handling qualities may leave something to be desired and the crushing strength factors are generally much less. In the data to be presented herewith, two grades of "Epocore" are compared—Grade A consisting of a 5/16 inch average diameter aggregate; Grade B consisting of a 9/16 inch average diameter. The optimum amounts of epoxy resin to use in bonding them are carefully evaluated for therein lies the key to successful utilization of large aggregates at low cost. It will be apparent that beyond a certain quantity of resin binder, further additions contribute only to the cost and not to the strength.

In Figure 2 are presented data demonstrating the crushing strengths of non-restrained castings of Epocore and an epoxy resin, identified as Epocast 2, activated with 20% safety Hardener 989. The castings were in the shape of truncated cones, measuring 1-⅜" diameter at its small-

This paper was presented at the February Thirteenth meeting of SPI.

Figure 2

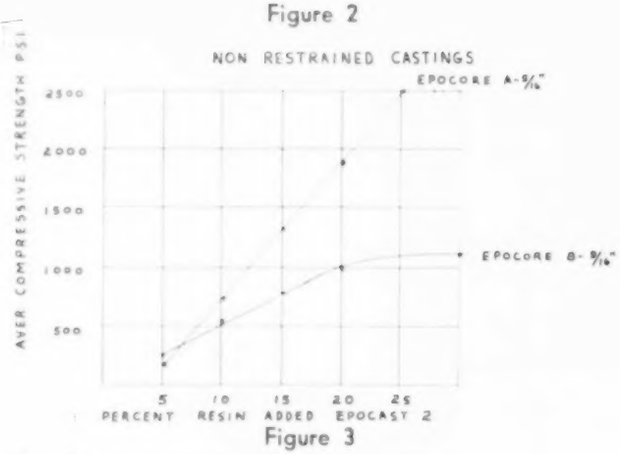


Figure 3

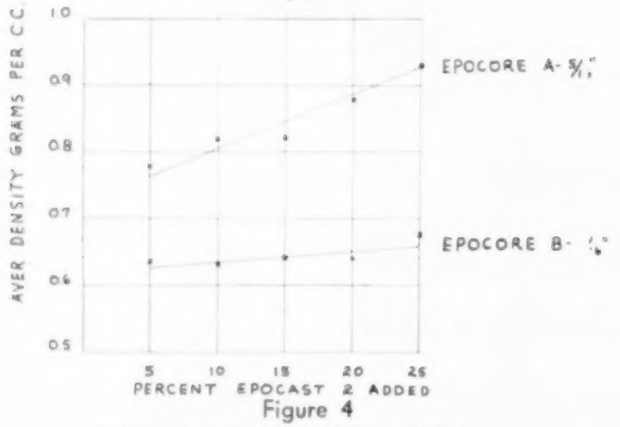
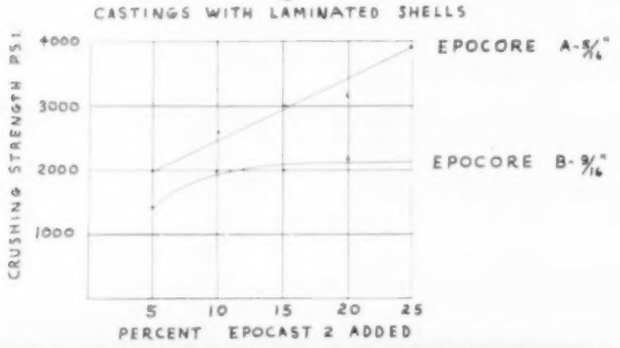


Figure 4



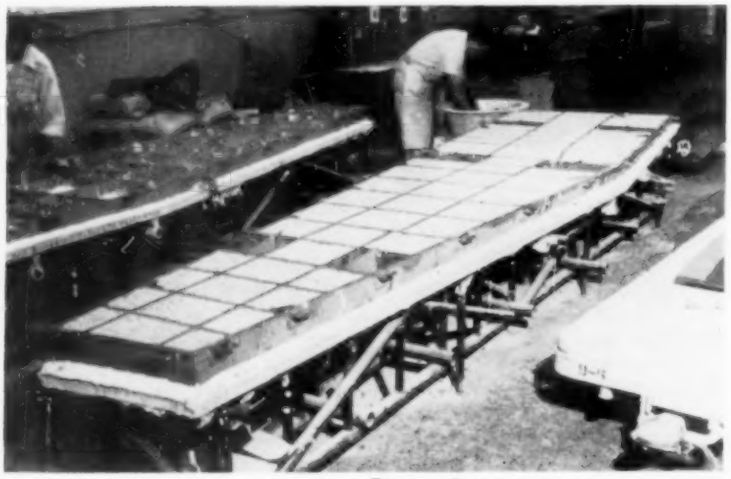


Figure 5

Reverse side of vacuum chuck used on tapered skin mill at North American Aviation, Inc.

est cross section, approximately 2" at its major diameter, and 2-½" high. Breaking load divided by area of smallest cross section was arbitrarily taken as the crushing strength (compression) in pounds per square inch. Castings were cured for three days at 70 to 80°F before testing them to destruction in a Tinius Olsen universal testing machine. Results represent the average of three tests.

Dependence on Resin Amount

It is interesting to observe that the more finely divided Epocore A, which screened through 5/16 inch mesh, showed a marked dependence on the amount of epoxy resin employed, whereas the larger Epocore B does not demonstrate the same reinforcing effect. For all practical purposes, ten to fifteen percent resin binder has been adequate for the latter aggregate material. The curves do not approach zero load with zero percent resin because with less than five percent resin added the distribution is too great to achieve any significant bonding effect. Data was repeated with a filled epoxy resin, Epocast 2-D, with substantially the same results as achieved with Epocast 2.

Average density of resin and Epocore was also measured for Epocore A (5/16") and Epocore B (9/16"). The results are again unusual, though they explain why the smaller aggregate demonstrates the greater crushing strength. Figure 3 illustrates that as the resin content is increased the density rises rapidly for Epocore A suggesting filling of the interstices between aggregates. In the range examined, Epocore B did not show nearly as marked a rise in apparent density as the resin addition was increased.

Cloth Outer Reinforcement

The data in Figure 4 illustrate the benefit accruing from a two ply glass cloth reinforcement as the outer shell reinforcement for the castings, described above. This is the practical example of using Epocore, a laminated glass cloth working face, as in a stretch die or hydropress form block, backed up with Epocore. Obviously, the laminated shell bears the brunt of the working stresses and the core serves as a space filler merely to stiffen the shell and distribute the compression loads. However, once again the reinforcing effect of the smaller Epocore A is apparent as well as the greater density both dependent on the resin added. Epocore B soon reaches a peak in volume demonstrating a practical maximum limit of epoxy resin in the vicinity of ten percent. Crushing strengths in pounds per square inch are much greater for the restrained, laminated shell reinforcement for the coarse aggregates than without the laminated shell, as reported in Figure 2.

It is also desirable to report that apparent shrinkages for the Epocore aggregates and epoxy resin are much lower than those observed for the fluid, pourable filled consistencies of epoxies. Furthermore, the exothermic heat is dissipated and the internal temperature rise during chemical cure is virtually negligible. Figure 5 demonstrates a plastic tool backed with Epocore.

Summarizing the benefits of aggregate reinforcements for plastic tooling, we find the following:

1. Lowest cost space filler.
2. Densities about one-half of cast epoxy resins.
3. Adequate crushing strength—about 2,000 psi.
4. No special equipment for mixing and handling (cement mixer will do.)
5. Exothermic heat is well dissipated.
6. Dimensional stability due to extremely low shrinkage on cure.
7. Service experiences of over one year as reinforcements for large plastic tools measuring up to two hundred cubic feet. ★ ★

Dermatoses and Epoxy Resins

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. . . the handling of epoxy resins can cause severe skin disorders and lost working time. There is one way to avoid trouble . . .

NUMEROUS FACTORIES in which epoxy resins have been introduced have reported the occurrence of pathological skin disorders (dermatoses) in a number of workers, both male and female. It is an interesting observation that employees in paint factories, where these synthetic resins are also processed, only rarely exhibited such phenomena. This appears to indicate that operators who were not accustomed to handling chemicals exposed themselves carelessly to the harmful skin action of these resin systems.

The first observations of such phenomena (7) led to the conclusion, after experiments on 20 operators using amine-cured epoxy systems, that contact with these products led to allergic epidermal eczema.

E. Grandjean, Director of the Institute of Hygiene and Industrial Physiology of the Swiss Federal Institute of Technology, carried out an investigation in eleven electrical manufacturing plants in which amine-cured epoxy resins were used. The results of this investigation are the basis for this paper.

Atmosphere

The atmosphere of each workroom was first examined for its amine content on the assumption that the cutaneous affections, which usually first appear on the head of the operator, might be caused by volatile constituents of the hardener. The concentration of amine in the atmosphere at head height at the workbench was too low to be measured by the method employed.

Observations at the workbenches soon indicated important sources of cutaneous irritation. Isolated droplets are constantly being spilled during mixing and especially during casting of the system. These droplets then fall on, or are wiped up, with the fingers. The workbench is dirtied by stirrers, spatulas, and brushes which are placed on it. The impurities are then wiped up with rags soaked in solvents such as acetone, alcohol, methyl ethyl ketone, and trichlorethylene. The same rags are also used to remove splashes and drops from hands and arms. In this way, dilute resin-hardener mixture is rubbed into the pores of the skin. Traces of the mixture are thus carried all over the workroom and reach the skin and clothes on various occasions. The operators are thus in permanent contact with the resin-hardener mixture, even after evaporation of the solvents.

Skin Attack

The action of the resin-hardener system on the skin usually proceeds as follows:

After an interval free of symptoms, which may last a week or many months, red patches (erythema) about the size of a coin first appear. These patches itch intensely. They first appear on the underside of the lower arm or in the region of the lower eyelid. They also often appear on the back of the hands, on the fingers, and on various parts of the face and neck. This first stage may heal by scaling of the patches after a period of several days to three weeks and the itching then disappears.

If the first stage of the dermatosis does not heal, the second stage consists of the formation of a true cutaneous eruption with red pimples and the formation of blisters. The intense itching causes the patients to scratch open blisters and skin. The inflamed parts of the skin are swollen, deep red, and wet with exuding tissue fluid. Continuation of work is no longer possible at this stage. If the eczema heals later, it first scales and then disappears after several weeks.

Skin "Hardening"

Observation showed that in some operators the dermatosis never goes beyond the first stage; in other words, adaptation of the skin, i.e., desensitization, may occur. As in other cases of occupational dermatosis, operators are best **not** removed from the workbench at the first symptoms of irritation so that they may have the opportunity of adapting or desensitizing themselves.

Plant Study Data

Grandjean's investigation of 328 workers from eleven factories showed that, on the average, 21% of the operators suffered from slight and 22% from severe derma-

This paper was presented at the Southern California SPE Section Regional Conference.

tosis. It was found that the extent and frequency of epidermal contact with the resin-hardener mixture was of decisive importance for the frequency of occurrence of dermatosis. No regular pattern concerning the localization of the epidermal irritations or eczema could be established. It may, however, be assumed that both the uncured resin and the hardener alone are capable of causing epidermal irritations. It was definitely established that vapors of the resin or hardener can cause a recurrence of the epidermal irritation or eczema in sensitized persons.

Preventive Measures

As a result of his observations Grandjean recommends a series of preventive measures which should be strictly observed. These suggestions can be summarized as follows:

1. **Thorough instruction** of the inspectors and foremen concerning the danger of working with resin and hardener, the nature of the skin irritations, and the measures to be taken to avoid them.

2. Arrangement of the workroom in accordance with hygienic requirements.

3. **Good ventilation** of the workroom; and, if necessary, installation of an air exhaust at each workbench.

If the volume of air in factories using epoxy resins amounts to less than 500 cu. ft. per casting workbench and more than 5 lbs. of epoxies are cast per day, then casting should be done in glass hoods with a powerful, local exhaust fan. If the volume of air per casting operator is larger than 900 cu. ft., and if the cast resin-hardener mixture is not cured in the immediate vicinity of the workbench, then changing the air in the workroom three to four times daily is sufficient. This kind of proper ventilation can be achieved by a window with an upper tilting wing.

Even the best ventilation is useless, if direct contact with the skin can occur during processing. Clean working habits must therefore be insisted upon in the first place.

4. a. **The workbench** should be covered with paper, which should be renewed twice daily.

b. The workroom should be provided daily with new, unused cleaning rags. Gloves should be worn during cleaning.

c. The use of solvents should be reduced to the absolute minimum. Gloves should be worn for all cleaning work in which solvents are employed.

d. Use of suitable containers of sufficient size and provided with a spout for mixing and casting resin and hardener. The use of cardboard containers which can be discarded after use makes cleaning unnecessary.

5. **Individual protection of the skin.**

a. The safest and most effective protection of the skin is afforded by the wearing of gloves. The disadvantages and possible skin irritations connected with the permanent wearing of rubber gloves can be avoided if leather gloves with a knitted upper surface be worn for manipulating resin and hardener. Wearing cotton gloves under rubber or plastic (polyethylene) gloves is advantageous in certain cases. Finger stalls offer a certain amount of protection in the case of delicate work which renders the wearing of gloves impossible. The gloves should be washed daily with soap and warm water, preferably while they are still on the hands of the operator. They should then be dried and kept in a clean place. Powdering the inside with talcum powder is to be recommended. In any case, the fundamental rule also applies here, that wearing of gloves does not obviate the need to observe absolute cleanliness.

b. Even though protective cutaneous ointments are rapidly rubbed off the parts of the hands coming into contact with the work, the use of such ointment does protect the back of the hands, the forearm, and the face to a certain extent; at least splashes are washed off more easily. The ointment should be applied before beginning work in the morning and afternoon, after having carefully washed the parts of the skin affected; then should be removed by washing after the work is finished.

c. The frequent occurrence of skin irritations on the underside of the forearm proves the importance of protecting the arms from contact with impurities on the workbench. The wearing of plastic cuffs is to be recommended. The cuffs should be washed immediately if they become dirty, otherwise regularly twice-weekly with soap and warm water.

The best overalls consist of aprons fitting tightly at the neck and with long arms. White overalls are to be recommended because they facilitate control of cleanliness and accustom the operator to absolute cleanliness. Changing of overalls each week should suffice if work is carried out carefully.

6. **Individual care of the skin.**

a. The hands should be washed with mild soap or emulsions before and after work, before and after going to the lavatories, before and after lengthy interruptions of work, and each time immediately after they came into contact with liquid resin or hardener.

The finger nails should be cut short and kept clean.

When the hands have been washed after work, application of a mild ointment containing oil or fat (one-half lanolin plus one-half Vaseline) is to be recommended.

b. Washing facilities in the proximity of the workbench are useful. In any case, the operators must be given sufficient time before work begins for care of the skin.

7. **Medical measures.**

a. Operators should be examined before hiring in order to exclude persons who have already suffered from allergic affections or are constitutionally predisposed to them.

b. Therapeutic measures.

For slight irritations: desensitization or "hardening" should first be attempted. If eczema occurs use special medical treatment along standard lines (e.g., oil or water emulsions as bland pastes, pasta refrigerans borata, and lanolin-Vaseline ointments). Antihistamine drugs should be used, if at all, only to reduce the itching. ★ ★

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Acknowledgment

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Flow Behavior and Turbulence in Polyethylene

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A fairly low molecular weight polyethylene was extruded by means of a large capacity, piston type extrudometer. This instrument was designed to give extruding pressures up to 20,000 pounds per square inch, which is approximately ten times the pressure commonly used for such investigations. Other advantages of this extrudometer will be brought out in the body of this paper.

The effects of temperature, pressure and tube diameter upon the rate of flow of the polyethylene were studied along with their relationship to the effective viscosity of the extruded material. The relationship of the rate of flow to the final diameter of the cooled polyethylene cylinder was studied for all the temperatures and tube sizes used. An effort was made to obtain a better understanding of the phenomenon of turbulence in plastic materials.

THE EASE with which thermoplastic polymeric materials may be plastically deformed at relatively low temperature is at one and the same time their greatest virtue and their greatest drawback. Because these materials flow readily at only a few hundred degrees Fahrenheit, they may be extruded or injection molded into the desired shape with relatively short heating and cooling cycles. On the other hand since the fabricating temperature is so close to the temperature of use, cold flow and creep become a problem.

The mechanical properties of thermoplastics at their service temperatures have been the subject of numerous investigations, but too few data can be found in the published literature about their properties at fabricating conditions. It would appear that if we are ever to have a clear understanding of the problems involved in extrusion and injection molding we must first become familiar with the fundamental properties of these polymers at their fabricating temperatures and pressures.

Spencer and Gilmore (1) (2) (3) have studied the flow of thermoplastic material in a glass-walled injection mold. The results of these studies indicate the necessity of knowing the viscous and elastic properties of the molding materials at the fabricating temperatures and pressures before a quantitative analysis of the molding process can be undertaken. Investigations of flow properties have been made by Dexter and Dienes (4), Spencer and Dillon (5) (6), Greenblatt and Fenson (7), Nason (8) and Hedstrom (9) to determine the visco-elastic properties at molding temperatures. Unfortunately these studies were carried out at relatively low pressures and to use these data requires the assumption that the viscosity of the polymer is not affected by the applied pressure.

For the work described in this report, equipment was developed which permitted the measurement of the apparent viscosity and flow behavior of polymers at temperatures up to 400°F. and pressures up to 20,000 psi.

Polyethylene was selected for this initial study because it was desired to use a material which was not plasticized and which would not decompose or degrade readily at the temperatures used. A fairly low molecular weight uninhibited polyethylene was used for this investigation.

A major part of the research reported here was sponsored jointly by the Army, Navy and Air Force under Signal Corps Contract No. DA-36-039-sc-133 and was published in another form in the Princeton University Plastics Laboratory Technical Report 27A.

Basic Theory

For a Newtonian liquid the rate of shearing is related to the applied stress by a constant. A plot of the rate of shearing against applied stress for a Newtonian

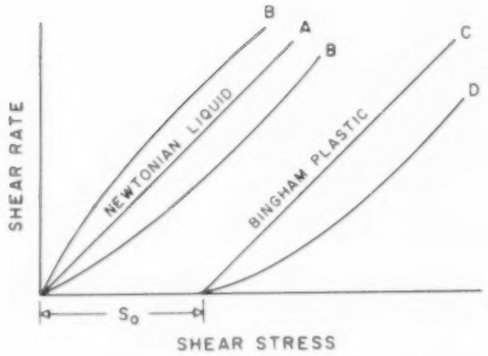
This paper was presented at the Thirteenth SPE Technical Conference.

Figure 1

FOR NEWTONIAN LIQUIDS

$$\frac{d\gamma}{dt} = \frac{1}{\mu}\tau$$

$\frac{d\gamma}{dt}$ = Shear Rate
τ = Applied Shear Stress
μ = Viscosity Coefficient



FOR BINGHAM PLASTICS

$$\frac{d\gamma}{dt} = \frac{1}{\mu}(\tau - S_0)$$

S_0 = Yield Stress

Figure 2

FOR NEWTONIAN LIQUIDS

$$Q = \frac{\pi P R^4}{8 \mu L}$$ = Volume Rate Of Flow

P = Pressure Differential
R = Tube Radius
L = Length Of Tube
μ = Viscosity Coefficient

REYNOLDS' NUMBER

$$N_R = \frac{\rho U D}{\mu} = \frac{4 \rho Q}{\pi \mu D}$$

D = Diameter Of Pipe
U = Mean Velocity
ρ = Mass Density

N_R For Turbulence In Liquids Flowing In Pipes Ranges In Value From 2000 To 3000 Depending Upon :

1) Surface Finish Of Tube
2) Entrance Configuration
3) Other Disturbances

liquid will give a straight line such as (A) in Figure 1.

Deviation from this straight line such as (B) indicates non-Newtonian flow. If some finite yield stress must be reached before Newtonian flow takes place then the rate of shearing follows the Bingham equation as shown in curve (C). If high polymeric materials at their fabricating temperatures were either Newtonian liquids or Bingham solids the problem would be greatly simplified. Unfortunately this is seldom, if ever, the case. In general most plastics exhibit non-Newtonian flow after reaching a rather indistinct yield point, as shown in curve (D).

Rate of Shearing

This means that for each rate of shearing or applied stress a different viscosity coefficient is exhibited. This curve with its continually varying slope will of course be different for various temperatures with the result that to describe completely the behavior of these materials we must determine a whole family of curves for all useful values of applied stress and temperature.

The most convenient method of measuring these qualities is by determining the flow through a circular cross section tube at various applied stresses and temperatures.

The equation of Poiseuille for the volume rate of flow (Q) through a circular tube as shown in Figure 2 can be derived by making the following assumptions:

(1) The fluid is Newtonian.
(2) Laminar (non-turbulent) flow exists.
(3) The pressure differential (P) is accurately known.
(4) Steady state flow exists (no accelerations).

In light of the assumptions mentioned above used in deriving Poiseuille's equation it is evident that the extrusion type of apparatus can be in error in that the equation is applied to non-Newtonian materials, often to turbulent flow, and that the pressure assumed to be the driving pressure is in error unless entrance effects are corrected.

Treatment of Deviation

Of these three violations of the basic assumptions mentioned above, the first two must be tolerated, since the material cannot be changed from its non-Newtonian character and since all we are seeking is an apparent or effective viscosity, realizing that the word viscosity has, to a considerable extent, lost its meaning with the materials under investigation.

The entrance loss of driving pressure introduces an error for which corrections must be made. Since the materials we are working with are not purely viscous it is impossible to calculate the entrance loss. This difficulty has been overcome by calibration of entrance orifices at the various test conditions.

Before leaving this discussion of basic flow theory some mention may appropriately be made of Reynolds' number and the phenomenon of turbulent flow. Reynolds' number is a dimensionless ratio relating the inertia force in an hydraulic system to the viscous forces of the system (Figure 2). If the flow for a particular model is dependent only on the inertia and viscous forces then, in order for the model and the prototype to be mechanically similar, the Reynolds' number for the model must equal the Reynolds' number for the prototype. In the case of the flow through a tube the mechanical phenomenon to be related from one size of tube to the other is the passing from laminar to turbulent flow.

For Newtonian liquids turbulence is experienced at Reynolds' numbers over 2000 and usually ranging up to

about 3000. The critical value of Reynolds' number depends upon the surface finish of the tube, entrance configurations and other kinds of disturbances.

For plastic materials forces other than viscous and inertial, namely intermolecular cohesive forces, or yield forces, enter into the material behavior. For a Bingham type material well above the yield stress the velocity distribution and general flow behavior should approach those of a Newtonian material and the Reynolds' concept may similarly apply.

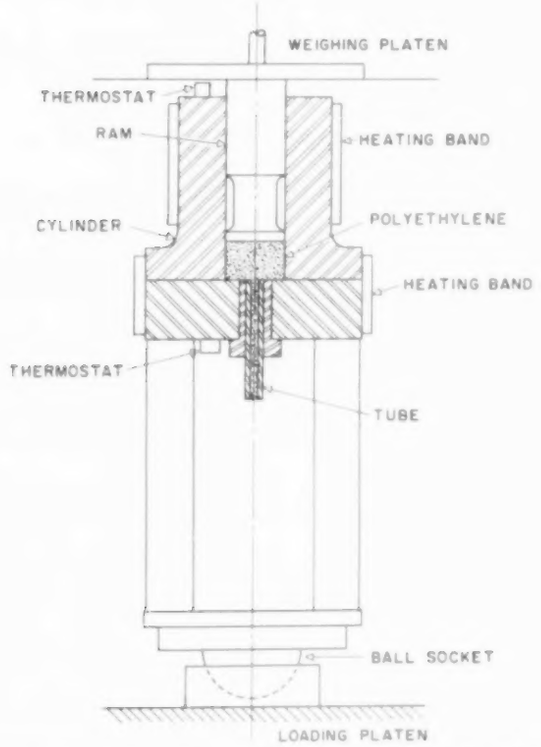
The Extrudometer

The extrudometer consists of a steel cylinder, ram, and cylinder head. Into the cylinder head various sized tubes are screwed. The bore of the cylinder is two inches and the outside diameter is five inches, safely permitting pressures up to 20,000 pounds per square inch. A line drawing of the extrudometer in position for downward extrusion is shown in Figure 3.

Polyethylene in the form of two-inch discs was loaded at the top, the discs being used so that close, air-free packing in the cylinder was possible. After the discs were in place a load of a few hundred pounds was applied to squeeze the air from between the discs before heating the material.

Heat was applied to the cylinder by means of two large band heaters that girdle the cylinder completely at its two diameters. The larger diameter heater was controlled by a surface type thermostat located on the surface of the cylinder head. The smaller diameter heater was controlled by the same type thermostat on the upper surface of the cylinder. The temperature of the surface of the cylinder was thus maintained to within one or two degrees of the set temperature. However, these temperature fluctuations were damped out considerably by the time the heat energy reached the polyethylene on the inside. Heat transfer calculations indicated that 1-½ hours are sufficient to bring the complete volume of polyethylene up to temperature. The heating time was increased to three hours to be on the safe side.

Figure 3



For tubes that might protrude from the cylinder head as does the one shown in the figure, the entire extrudometer was enclosed in a temperature controlled box to prevent cooling of the end of the tube.

The application of pressure to the material through the ram was provided by a Baldwin Southwark 60,000 pound Universal testing machine. This load spread over the area of the two inch diameter ram gave an available pressure of close to 20,000 psi. Since fairly small tubes were used and the rates of flow were quite small in most cases, there was no problem in maintaining a constant load for long periods of time.

Typical Test Run

A typical test run would be conducted as follows. With the tube in the cylinder head, the charge of polyethylene was brought up to temperature and the load applied to the ram. With the load held constant an extruded length of polyethylene was collected over a measured length of time. Upon cooling, the diameter at the first end was measured, since stretching due to its own weight would reduce the diameter elsewhere. The weight of the collected piece was measured and recorded. Dividing this by the specific weight at room temperature and then by the time required to collect the sample gave the room temperature volume rate of flow or end product volume rate. This procedure was carried out for thirty or forty loads, ranging from the point where flow was just measurable to the point where the limit of ram speed was reached.

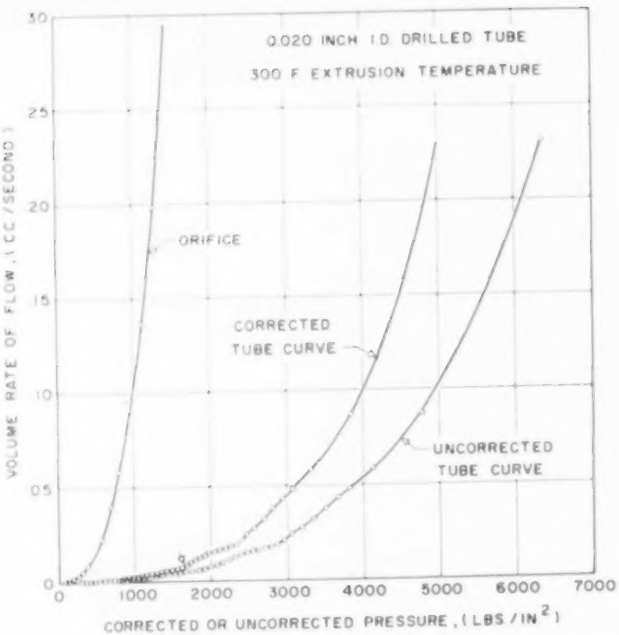
If the load is divided by the ram area, the pressure applied at the top of the cylinder is obtained. This is the equivalent to the pressure measured in the conventional type of extruding apparatus except for the addition of ram friction. Owing to a precision grinding job performed on the ram and cylinder bore the friction was so small as to be unnoticeable and no polyethylene ever squeezed past the ram.

Data Treatment

In order to remove from the pressure data that portion of the observed pressure which is due to any possible friction, shearing at the side walls of the cylinder, or entrance effects, another run was made with the same size hole as was used in the tube, but with no length. In other words we extruded through an orifice of the same diameter as the tube and collected the data required to calculate the volume rate of flow. This flow rate for the orifice was plotted against the pressure required to force the material through the orifice. From this curve it was then possible to find a correction pressure for any desired rate of flow (Figure 4). The pressure for the orifice-run that corresponds to the same volume rate of flow as for each point on the tube-run, was subtracted from the observed tube pressure leaving only the driving pressure that forces the extruded material through the tube. This correction which was subtracted from the observed tube pressure usually amounted to about 25% of the original observed tube pressure. The arrowhead on the corrected curve indicates the point on the curve associated with the start of turbulence.

This procedure has been carried out for four tubes all possessing a 20 to 1 length to diameter ratio. The four tubes, 0.125", 0.059", 0.040" and 0.020" in diameter, were used at four temperatures, 250°F., 300°F., 350°F., and

Figure 4



400°F. The 0.125" and 0.059" tubes were made of extruded steel, while the 0.040" and 0.020" tubes were drilled.

Results

A curve of side wall shear stress against side wall shear rate for each of the four extrusion temperatures was plotted on log-log paper for each of the tube sizes. (Figures 5A,B,C and D). Each curve is observed to have two straight line portions. The change of slope which is marked with an arrowhead represents the incidence of turbulence or roughness of the extrudate. At any given shear stress the shear rate increases with increase in extrusion temperature. For each of the tubes a straight line, shown dotted, serves as the locus of the incidence of turbulence over the temperature test range.

By replotting just the sixteen points associated wih the beginning of turbulence for the four tubes and the four extrusion temperatures investigated it was observed that a straight line on the log-log plot serves as the locus for incidence of turbulence for a specific temperature (Figure 6). Within the range of conditions investigated it is possible to approximate the point of occurrence of turbulence for similar tubes of other diameters at any temperature within the range of 250°F. to 400°F.

Prediction of Turbulence

The prediction and control of the occurrence of turbulence is of the utmost importance to the manufacturer of extruded thermoplastics for two reasons; the first being the more obvious one of increasing the flow rate through his extruders and the second being to have the greatest uniformity of cross-section of the extrudate. Figure 7 shows the final diameter of extrudate from an 0.040 inch diameter tube at 350°F as a function of corrected extrusion pressure and rate of flow. Similar curves were observed for the other tube sizes and temperatures of extrusion. The region of turbulence would be just beyond the last point plotted on either curve. Near this region fairly large fluctuations in pressure or flow rate would have little effect upon the final diameter of the extrudate compared to the effects observed along the steeper part of the curve.

Reiner (10) has suggested two possibilities for the cause of roughness of extruded viscoelastic materials, the Reynolds' turbulence on the one hand and structural turbulence or structural breakdown on the other. The latter theory has been supported recently by Tordella (11) under the name of melt fracture. According to this theory the criterion of roughness is a critical maximum shear stress at and above which the extrudate becomes increasingly irregular.

The Reynolds' turbulence theory states that for tubes of similar roughness and configuration the Reynolds' number at the occurrence of turbulence for one diameter tube should be the same as the critical Reynolds' number for any other diameter tube. Many investigators have tried to put the Reynolds' number theory of turbulence to the test on viscoelastic materials. Most have been

Figure 5A

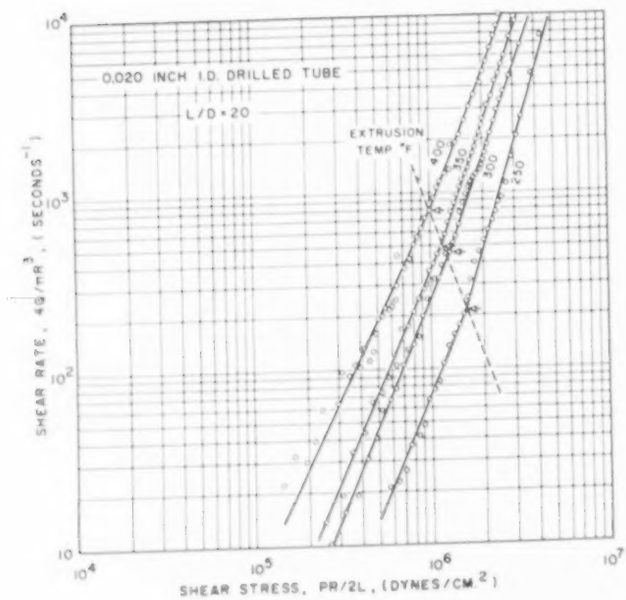


Figure 5B

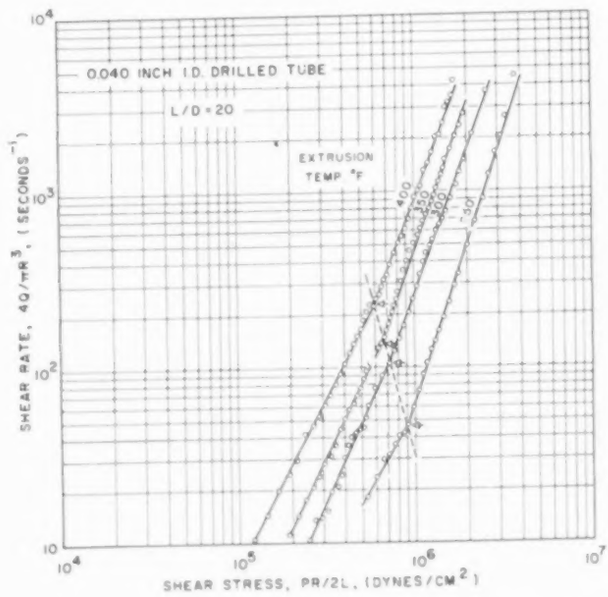


Figure 5C

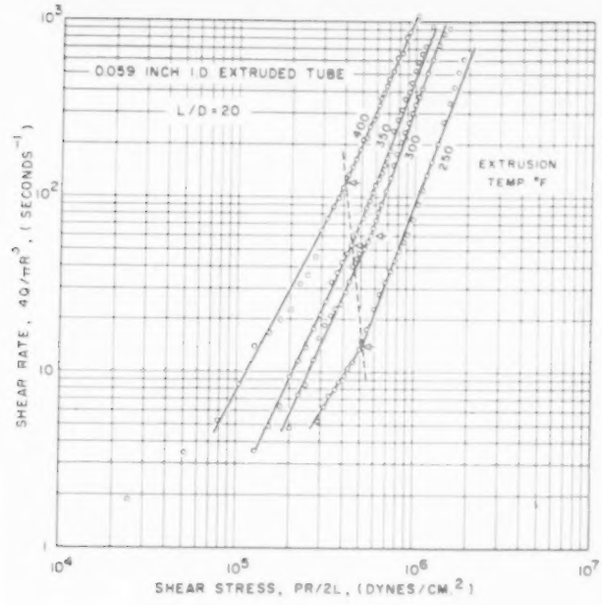
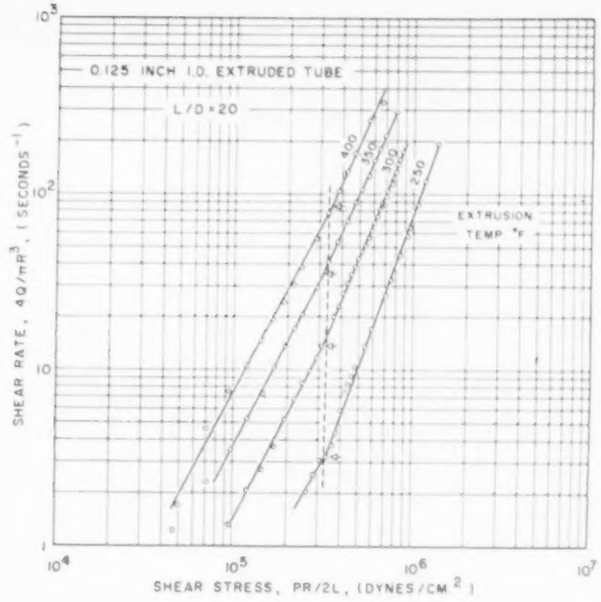


Figure 5D



Above and on facing page.

Stress—shear rate data at tube sidewall show beginning of turbulence.

Left

Summary of data of figures above.

Below

Extrudate diameter as function of flow rate.

Figure 6

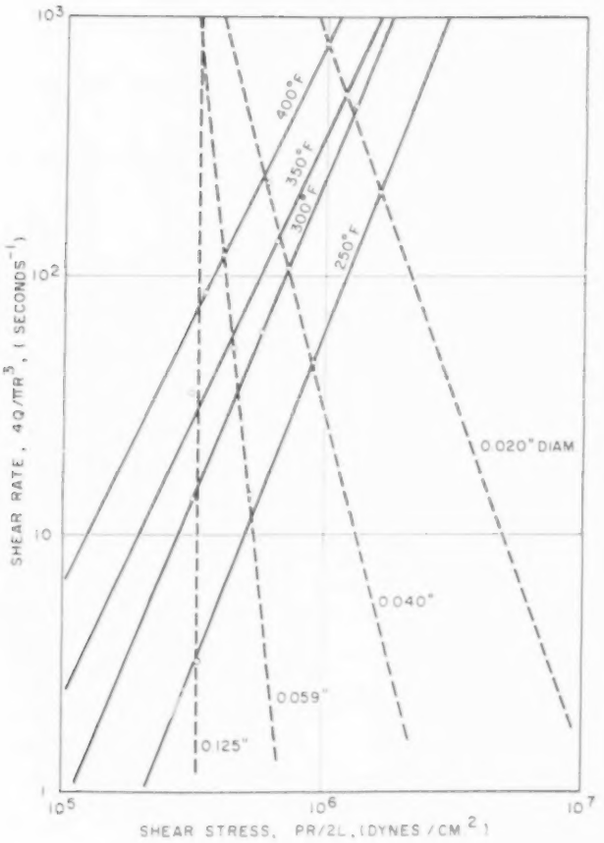
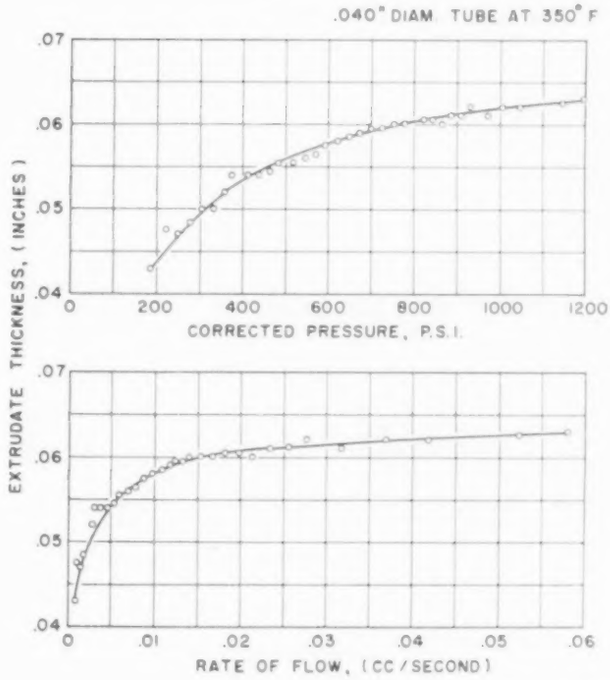


Figure 7



Shear Rate — Shear Stress for Four Tubes at Each Temperature

Figure 8A

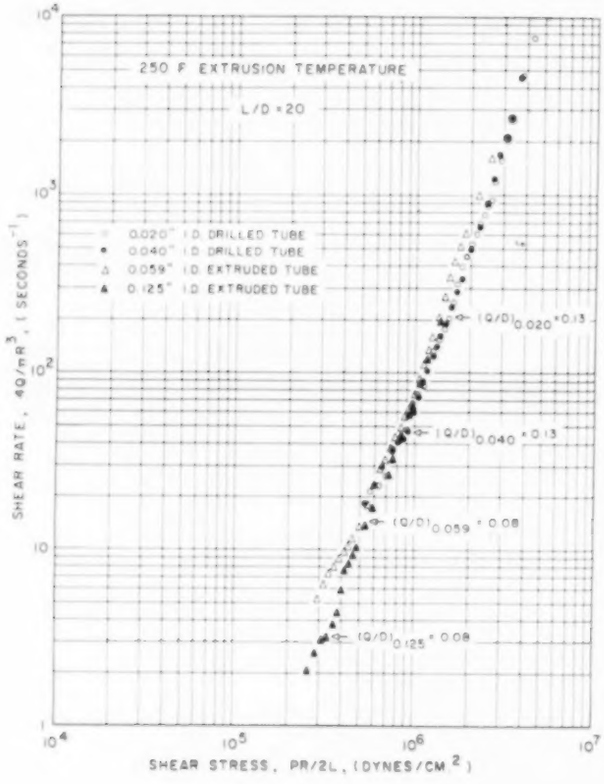


Figure 8B

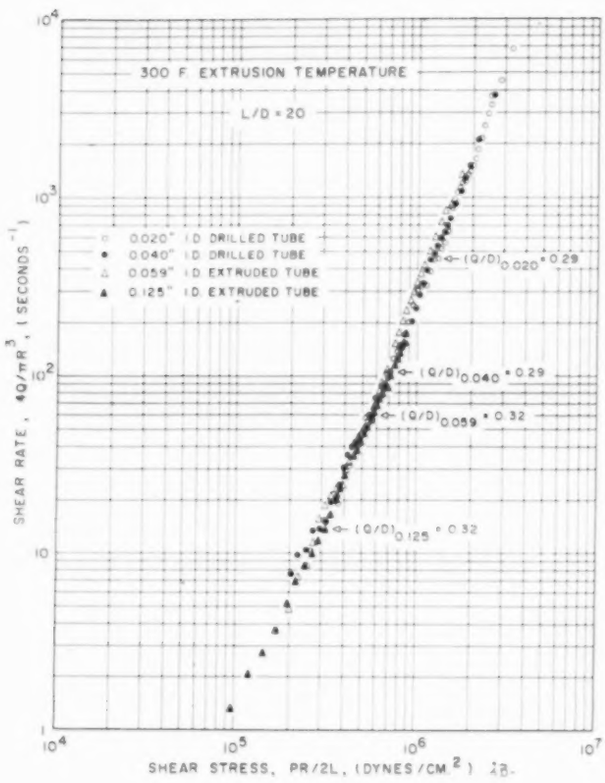


Figure 8C

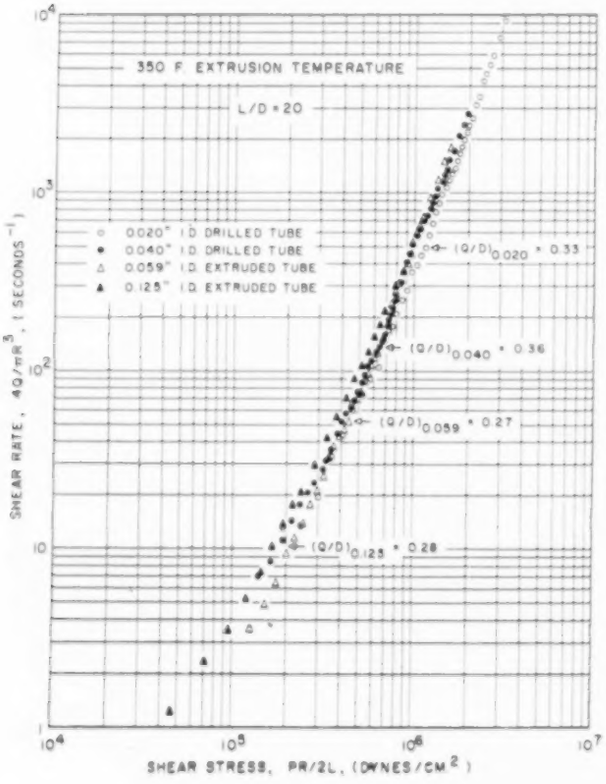
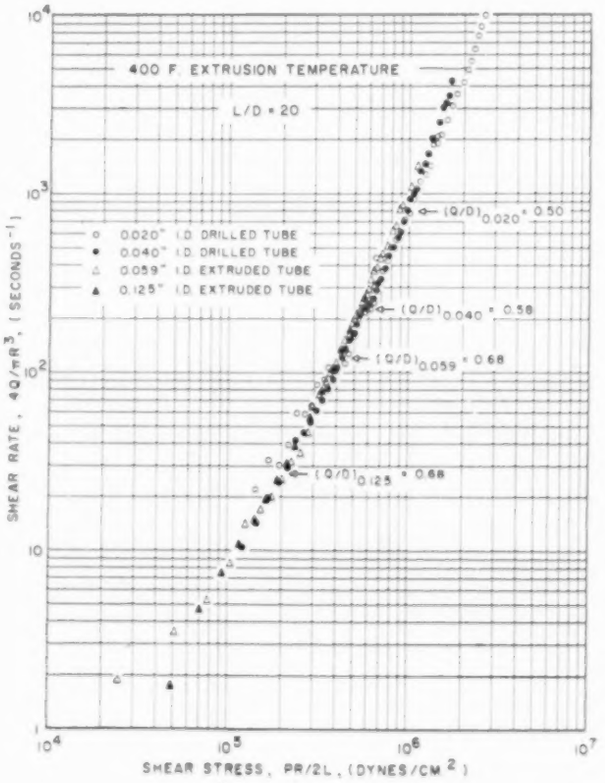


Figure 8D



deterred by the fact that the viscosity values required to make the Reynolds' number value the same order of magnitude as that associated with turbulence in liquids must be considerably lower than any reported apparent viscosities for polymer melts.

The Reynolds' turbulence theory can be tested without actually knowing the Reynolds' number value or the turbulence viscosity. Referring back to the Reynolds' Number equation in Figure 2, for a specific temperature if we can assume that the viscosity and density are constant, then the (Q/D) value at inception of turbulence should be the same for tubes of similar surface and configuration.

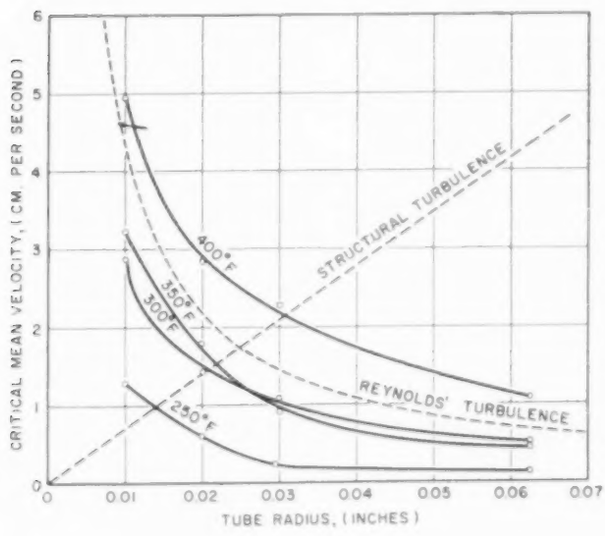
The log-log plots of shear rate against shear stress for the four tube diameters are plotted together for each extrusion temperature (Figures 8A,B,C and D). For each of the four extrusion temperatures the flow curves for all four tube sizes fall one upon the other. The arrowheads indicating the point above which turbulence takes place for the four tubes seem to indicate that the structural turbulence or melt fracture theory does not hold for the results of this investigation. At a particular temperature turbulence occurs at lower values of shear stress as the tube diameter increases. This agrees with the experimental results published by Alves (12).

Theory Check

To check the Reynolds' turbulence theory the value of the critical (Q/D) for each tube size is given to the right of the arrowhead. Very good agreement is observed between the two smaller drilled tubes and between the two larger extruded ones, but the pairs do not check with each other. The reason for this is that the critical Reynolds' number is a function of the surface roughness in the tube.

A further check on the nature of the disturbance can be made by superimposing our data upon a graph from the book by Reiner (10) (Figure 9). If the turbulence is structural or fracture in nature the critical mean velocity should vary directly with the tube radius. If there is a Reynolds' type turbulence the critical mean velocity should vary as the reciprocal of radius. The curves for our experimental results are all of the latter type.

Figure 9



Carrying the Reynolds' number theory a step further we can solve for the Reynolds' viscosity, the viscosity that the material feels and responds to at the brink of turbulence, in terms of the critical Reynolds' number which should be a constant (Figure 10). The Reynolds' viscosity against extrusion temperature curves for the four tube sizes are similar and all give a surprising result. Rather than having the Reynolds' viscosity decrease with temperature as does the apparent viscosity, there is an increase in viscosity by a factor of four.

Cummings and Lanza (13) show the effect of heating time upon polyethylene (Figure 11). The melt index

Figure 10

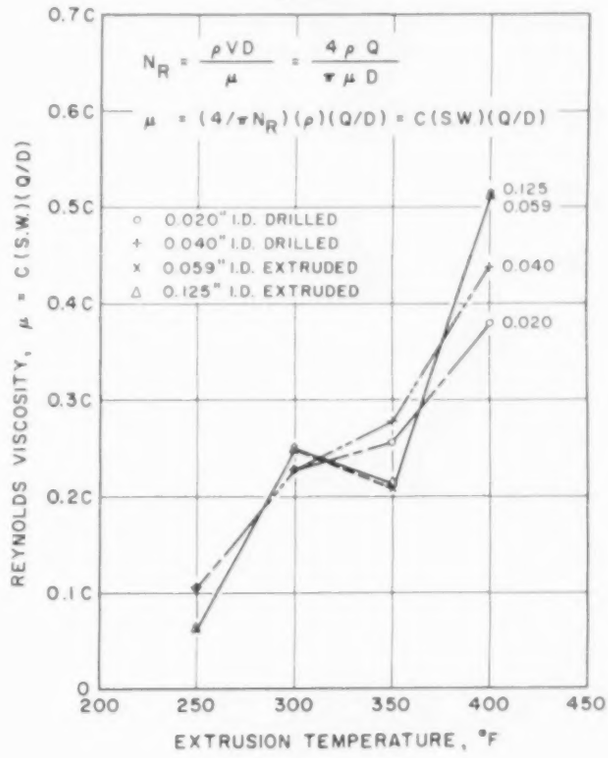


Figure 11

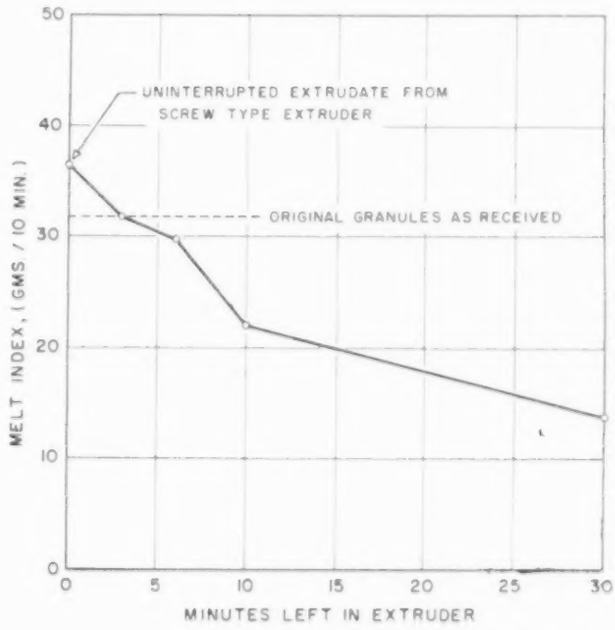


Figure 12

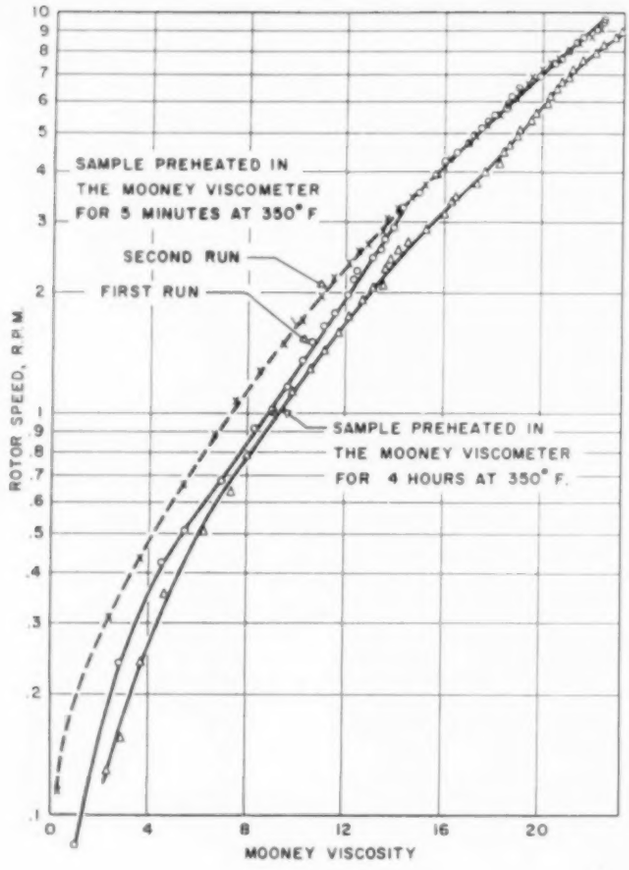


Figure 13

TEMP. °F	HOURS HEATED	[η]	β	k'	β + k'
AS RECEIVED		.963	.105	.403	.508
265	1/4	.965	.083	.418	.501
265	4	.963	.074	.427	.501
AS RECEIVED		.963	.105	.403	.508
400	1/4	.967	.077	.422	.499
400	4	.970	.050	.453	.503

of polyethylene at 400°F was lowered by a factor of two by allowing the flow from an extruder to be interrupted from its steady flow state for thirty minutes. This decrease in melt index corresponds to an increase in the apparent viscosity by the same factor. Three minutes dwell time in the extruder head were required to mend the reduction in the apparent viscosity caused by the extruder screw.

Mooney Viscosity

Vacca and Bebbington (14) have observed an increase in the Mooney viscosity with increased heating time in a Mooney viscometer equipped with a Bureau of Standards constant shear rate rotor (Figure 12). One sample was given five minutes heating time in the viscometer and the other four hours. The sample that was heated for five minutes was given a second run in the viscometer with speeds increasing from zero as was the case in the first run. The agreement observed at the higher speeds for the two runs of the same sample indicate that the reduced viscosity resulting from the work performed upon the material during the first run prevails throughout the second run. The curve for the sample that was heated for four hours in the viscometer shows an increased viscosity over that of the short heating time material. The curve for the longer heating time sample seems to retain its viscosity better than the first run of the short heating time sample.

The results from the above two references could be caused by a structural change such as branching or by a higher degree of entanglement of the molecules, or both, with the longer period of exposure to the extrusion or testing temperature.

Solution Viscosity

Solution viscosity studies made by Heiss and Wentz (15) upon polyethylene shed some light on the cause of the viscosity increase with time and temperature (Figure 13). The intrinsic viscosity, β and k' values are shown for their temperature-time dependence. Samples were molded with fifteen minute and four hour heating cycles at 265°F and 400°F. The solution viscosity results from these samples are compared with those results obtained from the original polyethylene as received.

No significant change was observed in the intrinsic viscosity or in the speed with which the samples went into solution. Therefore a substantial increase in molecular weight leading to gelation was not indicated. The β and k' values do show a significant change with time at both temperatures, the greater change occurring at the higher temperature. Cragg and Brown (16) have made a study of the effect of branching on the value of k' for polymers; an increase in the value is associated with the introduction of branching in linear polymers. This evidence of branching in polyethylene can account for an increase in the viscosity without any appreciable change in the yield stress.

An Explanation

Having substantiated that the Reynolds' viscosity can increase with temperature it is then necessary to explain why the apparent viscosity decreases with temperature at the same time.

The plasticising effect of heat in a polymer has the effect of increasing the distance between molecules or reducing the intermolecular forces. Therefore the yield stress should decrease with increased temperature. This was observed to be true.

The equation for flow of a Bingham material through a capillary can be expressed in terms of the yield stress or the radius of the flattened portion of the velocity distribution profile (Figure 14). Also shown in terms of the ratio of the radius of the flat to the radius of the tube is an equation for the ratio of the flow rate to that of a Newtonian liquid with identical viscosity. In terms of the yield stress, an increase in yield stress, a decrease in the pressure gradient, or a decrease in the tube radius all cause the Poiseuille equation to be less accurate in predicting the true viscosity of a Bingham material. Figure (15) shows graphically that a decrease in the yield stress with its accompanying reduction of the flattened portion of the velocity distribution profile can give a considerable increase in flow rate.

Conclusions

1. While the apparent viscosity of polyethylene decreases with increase in extrusion temperature the Reynolds' viscosity increases by a factor of four as the temperature increases from 250°F. to 400°F. due to the three hour heating period before extrusion.
2. The apparent viscosity of a material depends upon its time-temperature history. The apparent viscosity increases with time at elevated temperatures due to branching and possibly a higher degree of entanglement. The higher the temperature the greater will be the effect of time for the range of temperatures used in this study.
3. The diameter of the extruded rod increases with pressure or flow rate. The most rapid changes in diameter take place at lower pressures and flow rates. There is a leveling off to some limiting value of diameter as the point of turbulence is approached. Therefore, the greatest dimensional stability appears to be in this region approaching turbulence.
4. For a given extrusion temperature turbulence occurs at lower values of shear stress as the tube diameter increases.
5. For a given size of tube the point of turbulence occurs at lower values of shear stress as the temperature increases.
6. Turbulence in the extruded material is accompanied by a break or change in slope on a shear rate—shear stress curve giving two essentially straight line portions on a log-log plot. Knowing when turbulence occurs for one size tube makes it possible to predict when it will occur for the same material flowing through another tube with similar surface and entrance conditions provided the temperature is constant for both.
7. The Reynolds' turbulence theory for the prediction of the occurrence of extrudate roughness was found to fit the data of this investigation while the structural turbulence or melt fracture theory did not. ★ ★

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Figure 14

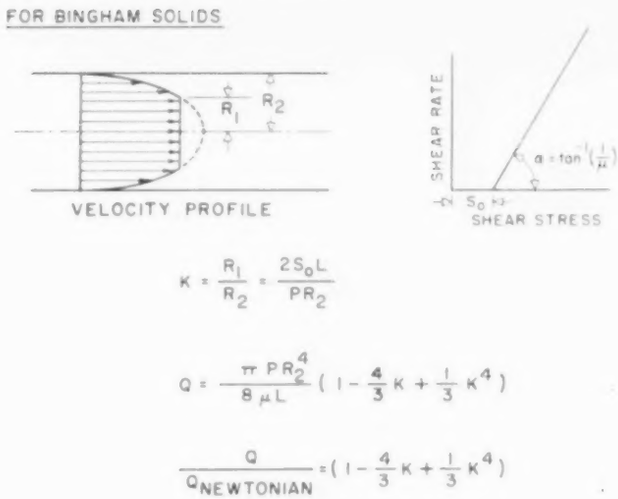
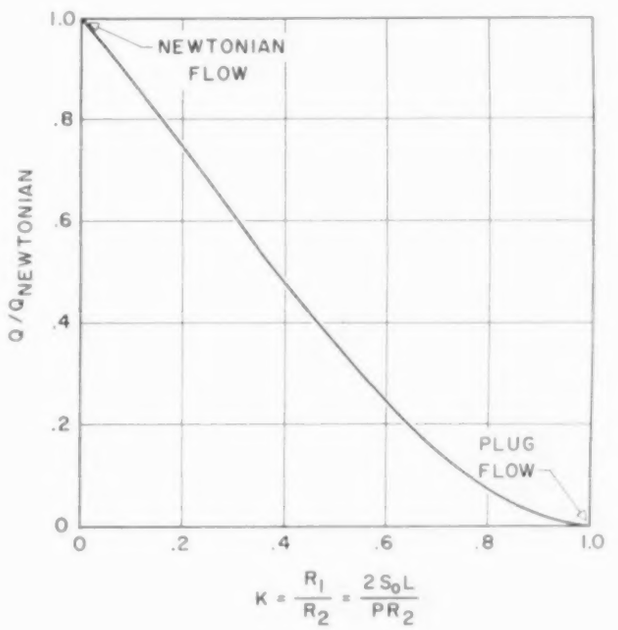


Figure 15



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A discussion of the results of this paper and the interpretation of the data follows on page 36.

Occurrence of Melt Fracture in Extrusion of Molten Plastics

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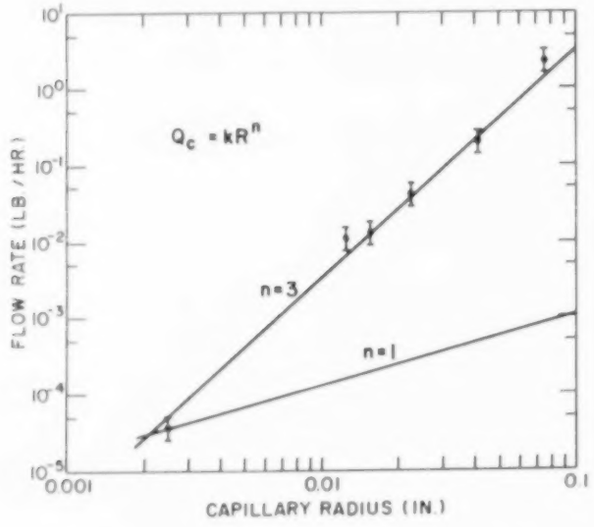
IN A RECENT paper, (5) R. F. Westover and Bryce Maxwell contradicted the results of other workers (1,2,3,) relative to the conditions under which melt fracture occurs in extrusion of plastics. Melt fracture results in extruded constructions which are commercially unacceptable because the surfaces are rough and irregular. On account of the practical importance of this phenomenon, it seemed appropriate to state the results of the two groups of workers and to present data which appear to demonstrate which of the two points of view is correct.

The physical phenomenon involved is the following. In extrusion of molten plastics through a die, there is a critical rate at and above which the shape of the extrudate becomes irregular. The magnitude of the critical flow rate at which this occurs varies with the temperature (1,2,), the contour of the inlet of the die, (2) and with the size of the die opening (1,2,3,4). It is the dependence of critical flow rate on die opening, specifically on capillary radius, about which there is a difference of opinion. Both groups of investigators agree that the critical flow rate, Q_c, is proportionate to some power, n, of the radius, R, of an extrusion capillary.

$$Q_c = k R_n$$

Westover and Maxwell (4) proposed that the value of the exponent **n** is 1. Other investigators (1,2,3) have indicated that **n** = 3.

The following experiment was carried out to provide definitive data. Critical flow rates were determined for capillaries whose radii varied thirty-fold in diameter. The investigation was carried out with a small ram extruder using "Alathon" 14 polyethylene resin at 300°F with flat inlet capillaries. The data are given in Table I and plotted in Figure 1. The lines indicate the dependence of critical flow rate on diameter predicted by equation 1 with **n** = 1 and **n** = 3.



Variation of Critical Flow Rate with Capillary Radius

Figure 1

Table I

Critical Rates at Onset of Melt Fracture — "Alathon" 14 Polyethylene Resin at 300°F

Capillary Radius (inches)	Critical Rate Data	
	Flow Rate (lb/hr)	Shear Rate ($4Q/\pi^3$, sec^{-1})
0.0025	0.000038	38
0.0125	0.012	78
0.0155	0.013	45
0.0233	0.041	43
0.0413	0.22	41
0.0751	2.2	76

The above data are described by the following equation which was fitted by the method of least squares.

$$Q_c = 6.580\ R^{3.14}$$

The reliability of the exponent 3.14 was ± 0.36 (95% confidence limits). Thus, the data are described by equation 1 when **n** = 3 within the reliability of the data. Clearly, the data cannot be fitted by **n** = 1.

It was also shown that the third power relation between critical flow rate and capillary radius was not characteristic merely of the particular experimental circumstances used. Similar results were obtained with the following different kinds of apparatus: (a) commercial screw extruders (both here and elsewhere (1)); (b) a ram extruder in which the ram was advanced at constant rate rather than with constant force; and (c) an instrument in which the extrusion pressure was supplied by gas pressure directly on the specimen. Furthermore, it was observed that the critical flow rates were unaffected by the presence of air bubbles in the melt.

The third power relation between critical flow rate and capillary radius was not peculiar to "Alathon" 14 polyethylene resin. Similar but less extensive data were obtained for several other polyethylene resins both linear and branched, and for a number of other resins including polystyrene(1), "Zytel" 101 nylon resin, and "Lucite" 140 acrylic resin.

Considering the evidence presented by the other investigators and the evidence presented in this letter, it appears that (a) there is a critical flow rate for any plastic at and above which the extrudates become irregular in shape, and (b) that the critical flow rate is proportionate to the third rather than the first power of the capillary radius. These considerations together with other experimental observations led to the conclusion that fracture(2) or sudden yielding(3) of the molten plastic in die inlets is the cause of irregular shapes which occur at a critical flow rate.

(Please turn to page 62)

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What the Plastics Engineer Should Know About . . .

Patents, Trademarks and Copyrights

Clarence F. Kiech
Member of the Los Angeles Bar

. . . patents, trademarks and copyrights present troublesome questions to plastics engineers. The present article discusses fundamental principles and is compiled from a talk presented to the Los Angeles Section on October 4, 1956 by the author . . . .

ENGINEERS INTERESTED in plastics are often faced with the question of statutory protection of their ideas through trademarks, copyrights, design patents and the usual or so-called utility patents. Within the scope of the present discussion, we can do no more than outline these subjects. Nevertheless, there is often such erroneous thinking concerning these matters as possibly to justify a review of basic principles. This will be here undertaken with particular relation to practical problems that may face the engineer or manufacturer working in the broad field of plastics.

In an attempt to make the discussion just as practical as possible, let us assume a purely hypothetical situation to which we can later refer as an example. In this connection, consider Harry Leake, a plastics engineer who has built up a business under the name Hypothetic Plastics, a corporation, in the mythical town of Mayfield, New Jersey. He has several injection molding and extrusion machines and a well-equipped machine shop for making the dies he uses to produce a variety of plastic items. Among these are plastic models of present-day and historical boats. The company also produces numerous household items among which are kitchen gadgets and a new plastic pitcher of unique shape, designed by an employee.

For Example

Hypothetic Plastics is interested in expanding its market and decides that there is a good future in a line of plastic tubing and fittings for general plumbing uses. Using considerable ingenuity from his engineering background, Mr. Leake designs and develops several items as follows. First, a line of elbows, tees and couplings, having threaded openings and shapes similar to those of galvanized pipe fittings except that they are made of a new high-strength plastic which Mr. Leake has formulated. Second, a method of locally hardening extruded tubing made of this new plastic, permitting hardening of the end of a length of tubing and then threading it to screw into any of the plastic fittings to make a good self-sealing plumbing joint. Third, an all-plastic valve of radically new design having a valve member carried by a polyethylene bellows to seat by fluid pressure in the line, as controlled by a small pilot valve. Fourth, Hypothetic Plastics has developed a kitchen sink fixture of unique appearance, incorporating two such valves and a swingspout of quite distinct design, the two valves being linked in such a way that one valve automatically opens to mix cold water with the hot water for an initial short period of time to prevent accidental scalding of the user.

Trademarks

Let us look first to **trademarks** to see to what extent they can be beneficial to Hypothetic Plastics in its program. A trademark consists of one or more words or a pictorial design applied to goods with the object of indicating their source or origin. Trademark rights can become extremely valuable through long and continued use. It is important to remember that fundamental trademark rights arise from actual use, not from registration. A manufacturer has common law rights in his trademarks whether or not he ever registers them in the U.S. Patent Office or in his own state.

The manufacturer or the seller selects a trademark, preferably after a search of existing marks, and begins to use it on the goods themselves. A mere use on letterheads, in advertisements or in sales brochures will not create trademark rights. Use on displays associated with the goods may be effective in creating such rights but the best way is to use the trademark by applying it to the goods or to the containers therefore. The dates of first use in one's own state and of the first interstate sale of the trademarked product are of fundamental importance in

establishing federal rights. Records of both dates should be made and preserved.

In our hypothetical situation, our manufacturer would obviously like to have a distinctive trademark for his new plastic plumbing items. He, like all men, would probably think first of using his own surname as a trademark. Mr. Leake wisely decides this would not present a desirable connotation for plumbing and valves. He was wise for another reason. Surnames are not usually the best trademarks. Except in a subordinate way, they cannot be registered until they have become distinctive of the manufacturer's goods or have achieved a secondary meaning by virtue of long and extensive use. Even if you succeed in registering a surname mark, it is sometimes impossible to prevent a competitor with the same surname from using his own name on his products, particularly if he does not copy the dress of your goods or palm off his goods as yours. Nevertheless the public is confused by his duplicative use and may not continue to associate your name with your goods.

Selection of Trademark

Next, our manufacturer might think of using "Mayfield" as a trademark. Here again, however, he will be wise to continue his quest for a good trademark because, under our assumption, Mayfield is the name of the town in which he is located and because geographical marks, like surnames, cannot usually be registered until they have been in use for a long period. The same conclusions follow should he consider using a mark descriptive of his goods like "Plasticpipe" or "Endthreaded" for his tubing items. His patent and trademark counsel will advise him that arbitrary or coined words are usually best, but that some marks that are merely suggestive of a property of the goods, rather than descriptive of the goods themselves, can often be built into valuable trademarks. As an example, his counsel would probably approve an arbitrary mark like "Saxin", "Mopa", or "Atol", and might agree that a suggestive mark like "Plentigood" might be permissible, all on the assumption that an adequate search of existing trademarks showed no other manufacturer was using a phonetically similar word on the same or related goods.

Even though fundamental trademark rights arise from use and not from registration, it is most desirable that trademarks be registered in the United States Patent Office. After the registration has been in existence for more than five years its use by the registrant becomes largely incontestable by others as to the goods listed in the registration. In addition, the registration not only gives the right to sue in the federal courts for trademark infringement but also makes of public record in the Patent Office the mark being used by the registrant on his goods. The latter has a valuable function not only of guiding other manufacturers away from this or phonetically similar marks, but also permitting the Patent Office to reject applications for trademark registration filed by competitors which might be confusingly similar to the registered mark.

Federal Registration

A federal trademark registration is obtained by filing a formal statement indicating the adoption and use mentioned above and specifying the goods on which the mark has been used and how the mark has been applied or used in connection therewith. A formal drawing may or may not be requisite. Five specimens or facsimiles of the mark as actually used in commerce must be supplied to the U.S. Patent Office, along with a statutory fee of $25.00.

Our manufacturer might find it necessary to file several different applications if the same trademark is to be used on all of its manufactured items. For example, one application might be required for use on the various plumbing fittings, another for the use on the new pitcher, and still another for use on the boat models. This is because the Patent Office has established classifications of goods and services with which the applications must conform, no application covering use on items beyond those in its particular class. Manufacturers often deliberately file in as many different classes as possible because this gives not only a more extensive coverage but makes the mark of record in a larger number of classes to impede others from adopting deceptively similar marks.

The Examiner's Search

Several months after the application is filed in the Patent Office, the trademark examiner will make a search of existing marks. If this shows that the trademark is not confusingly similar to any trademark previously registered or used on similar goods, the application will be allowed and published for opposition. If not opposed by others within 30 days, the registration will be issued.

Trademark rights can be maintained only by continued use. Under our present trademark laws, even an issued registration is automatically cancelled unless, between the fifth and sixth year of its life, the owner files an affidavit alleging that the mark is still in use or showing that its non-use is due to special circumstances, without intention to abandon the mark.

Federal trademark registrations are issued only to the actual user of the trademark, whether an individual, a partnership or a corporation. They have a term of 20 years and can be renewed for successive terms, as long as the trademark remains in use. One should not license others to use his trademark, without getting the advice of trademark counsel. By promiscuous licensing he may lose his trademark rights unless the licensing arrangement is very carefully set up and controlled. Also one's trademark should not be used in a generic sense as the common name of the product rather than a brand of the product. Remember, "aspirin" was once a trademark but was allowed to lose its trademark significance by being used as the name of the product rather than the "Aspirin" brand of headache tablet. Finally, remember that a trademark does not protect against duplication of the goods on which it is used, only against use by others of a deceptively similar trademark on similar goods.

Limitation on Coverage

How does one obtain protection against copying of the goods themselves? Only under our patent laws and, in imited circumstances, under the copyright laws.

While some patents and copyrights were issued by the Colonies, before the Declaration of Independence, the fundamental basis for copyrights and patents, as we know them today, is found in the Constitution, Article 1, Section 8, which gives Congress the power:

> "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

From this simple statement has evolved our complex copyright and patent laws.

Copyrights

Copyrights prevent others from making copies of certain classes of works, such as books, works of art, photographs, and the like. While certain common law rights come into existence as soon as the work is completed, we have federal copyright statutes preserving, formalizing and extending such rights and giving statutory relief for violation thereof. Statutory copyrights can

be obtained on either two-dimensional or three-dimensional items by suitable application to the Register of Copyrights, Library of Congress, Washington 25, D.C. That entity has set up a suitable classification of copyrightable works and requires the filling out of corresponding forms, obtainable free from the above address. Each of such forms gives general instructions concerning subject matter and procedure.

Typical of two-dimensional items are pages of printed material whether bound as books or pamphlets or whether existing merely as one or more individual sheets. Such works are copyrightable under Class A, Books, but it is vital to remember that a notice of copyright must be placed on all copies even before application is made for copyright registration. Anomalous as this seems, the magic words "Copyright (year) by (name of copyright proprietor)" must be placed on all copies when first printed and on all reprints. Within a reasonable time from the first distribution of copies, "Form A" must be filled out and mailed to the above address with $4.00 and two copies of the work. There is no novelty examination and the applicant usually receives back promptly the second page of the form he filled out, with certain signatures and seals making it the official copyright document. Hypothetic Plastics might desire thus to copyright some of its catalogs, brochures, advertisements or data sheets.

The "Work of Art"

Three-dimensional items which are the result of artistic craftsmanship can usually be registered in Class G, Works of Art, by filling out "Form G". Thus, articles that are primarily decorative or ornamental can usually be copyrighted, but not articles that are primarily utilitarian. For example, if the shape of an article is determined by the requirements of its utilitarian function a copyright cannot be obtained, but if an article otherwise shows artistic design features the mere fact that it is useful will not deny the possibility of copyright protection.

The notice of copyright on works of art must be present before copies are distributed and before copyright registration is solicited. Here the notice may be "©" followed by the name of the copyright proprietor and preferably the year date, e.g., "©, John Doe 1957." The name can be abbreviated or initials used if the full name appears elsewhere on the work. To obtain copyright registration, "Form G" should be filled out and mailed with a fee of $4.00 and two copies. If the item is bulky or unduly valuable, photographs meeting the requirements set forth in "Form G" can be substituted.

Scientific Products

There is another class of copyrightable material that may give rise to questions to those working in the field of plastics. This is Class I, Drawings or plastic works of a scientific or technical character, requiring completion of "Form I". This includes two-dimensional or three-dimensional works designed for a scientific or technical use. Examples would be diagrams or models imparting technical or scientific information, such as charts, anatomical models, three-dimensional birds for educational purposes, engineers' scale models, and so on. The word "plastic" is not used in the sense of requiring the presence of one of the synthetic chemical derivatives such as styrenes, but rather to connote a three-dimensional work giving the effect of being molded or sculptured.

Obviously, the new plumbing items of Hypothetic Plastics could not adequately be protected by copyright, nor could its trademarks. Those of its household items that are primarily for decorative purposes might or might not be held to be subject to copyright protection, depending largely on whether they would be considered to have creative authorship in their shape. The same is true of the models of ships and the new pitcher produced by the company. Usually, however, such articles are considered to be copyrightable.

Limit to Copyright Value

While a copyright is relatively inexpensive and while it extends for 28 years, being also renewable for a like term, it is of only limited value. Remember that a copyright does not protect the background ideas of a device, only the particular expression or form in which such ideas are present in the copyrighted work. The copyright law gives only the right to control the making of copies of a particular thing, not the right to prevent others from independently using the basic ideas or systems that are at the foundation of the work. For example, one can copyright a photograph of Yosemite Falls and thus prevent others from copying that photograph, but one cannot thereby prevent others from making and copyrighting their own photographs of the falls, even if taken from the same viewpoint. A manufacturer can copyright his brochure or catalog describing his products but this does not protect against copying and sale of the products. One can make a model of the Empire State Building and copyright it, but this does not give him the right to exclude others from making their own models of the building, only the right to prevent others from copying his model without recompense. It is not hard to imagine how difficult it is to sustain a charge of copyright infringement by proving actual copying of a previous work as distinct from working from original sources. Those relying on copyright protection will often deliberately incorporate a minute error or lack of symmetry with the thought that if the same disconformity is found in another's product it is rather strong evidence of actual copying. However, we must conclude that copyrights can be of only limited value to manufacturers of plastic articles.

Novelty Is Not Basis

While copyrighted matter must be original, it need not have substantial novelty. This is an important distinction from a design patent, which will next be discussed and which can be obtained only if its subject was not known or used by others in this country before the applicant's invention thereof or not described in any printed publication, here or abroad, before such invention.

Design patents cover the appearance or eye appeal of an article of manufacture. The appearance must be novel and inventive, either in ornamentation or shape or both. It is important to remember that design patents cover the appearance of an item, not how it works.

Applications for design patents must be filed in the name of the true inventor, although obviously they can be assigned if desired. Design patents are granted for terms of 3½, 7 or 14 years, depending upon the fee paid to the Patent Office and the term requested. Applications for design patents are subject to careful examination in the Patent Office and are issued only if the device is novel and inventive in its ornamental aspects. In other words, the design features must not be obvious to one skilled in the art and must not be an obvious change from previous designs or a mere assemblage of previous design features.

The design of the pitcher made by Hypothetic Plastics would be the subject of a design patent, if sufficiently novel and inventive. The same is true as to the appear-

ance features of its kitchen sink fixture with its distinctive swingspout. Some of its boat models might be the subject of design patents, but not if they are mere exact miniatures of actual boats. Many of its household items might be sufficiently distinctive in appearance to be the basis of design patents. Obviously, the pipe fittings would not be patentable because their external appearance is not new.

Design Patent

However, design patents are not the panacea for all the troubles of our manufacturer. Remember that they cover the mere appearance of an article and that an astute competitor can usually change the appearance to some extent and still market a competitive product. In addition, present delays in issuance of design patents, while less than in former years, are still far too long. In protecting industrial designs, particularly those having a relatively short life, we need new laws or regulations that will speed up and simplify obtaining protection against pirating by competitors. The patent bar is not blind to these needs and has standing committees working on the problem. One solution may be to establish an entirely new kind of design patent or petty patent of short life under laws with sufficient teeth to prevent the pirating of meritorious industrial designs.

In the present state of affairs, whenever you are faced with the problem of deciding whether a borderline invention should be protected through a design patent or through an ordinary mechancial patent, it is better to choose the latter. Let us now look to the requirements of such a patent and the protection afforded thereby.

Regular Patent

Ordinary patents for inventions, sometimes called utility patents, can be obtained for the following classes of subjects, assuming that later-mentioned statutory requirements are met:

First, a machine, an apparatus or a mechanical device performing some function and producing a definite effect or result may be the subject of a utility patent. A machine has relatively moving parts operating or coacting as determined by the mechanism itself. Remember that under this classification one cannot patent a mere principle or abstract idea, only a definite mechanism. Utility patents protect the structure and mode of operation of a machine, not the external appearance thereof. The all-plastic valve of Hypothetic Plastics would be in this class as concerns its mechanical features; also the automatic or structural features of its sink fixture.

Second, an article of manufacture may be the subject of a utility patent. Usually this will be something in the nature of a tool or a piece of furniture. Our manufacturer's kitchen gadgets might be subject to such protection; also its plastic tubing with locally hardened ends.

Third, a process or method of producing some physical result may be the subject of this type of patent protection. Thus, a series of steps performed in sequence on something to change it to a different state or condition may be patentable, albeit not the mere discovery of an abstract principle or a law of nature. The method steps by which Hypothetic Plastics locally hardens its tubing might be patentable as a process.

Fourth, a composition of matter may be patentable. This relates to the product which results from intermixing two or more components. It is thus concerned with ingredients. Chemical reaction between ingredients to produce a new chemical compound often spells patentability, as distinct from mere mixtures having no properties differing from those that would be expected from the several ingredients, e.g., the usual doctor's prescription. The new high-strength plastic developed by our hypothetical manufacturer might be patentable if of new chemical composition.

Patentability

Such patentability under our present statutes requires many things in addition to mere utility or operativeness. It is a prerequisite to file a patent application before there has been any abandonment of the invention and within one year of the first public use or sale thereof. Patent applications can be made only by the true inventor, although they and the inventions they cover can, of course, be assigned.

A primary requisite of patentability is novelty. Utility patents are granted only to the first inventor of a particular subject matter. The subject matter must not have been known or used by others in this country before his invention. If others have patented it earlier, or if it has been disclosed in public print or is a matter of common knowledge, our inventor might best forget his patent ambitions. If the Patent Office finds two inventors are claiming the same patentable invention in copending applications, it will set up a so-called "interference" to permit each to prove his dates, the patent protection being given only to the first inventor. Such interferences are complex proceedings, expensive and time consuming, and are based on a unique body of law with complexities far beyond the scope of the present discussion.

There is another requirement of patentability — the most troublesome of all. The advance must represent "invention." By this term the courts or the Patent Office examiners usually mean merely that the advance must be unobvious to the ordinary man skilled in the pertinent field of endeavor. In other words, to be patentable, an advance must represent more than the ordinary skill of the art. This is another way of saying that the advance must be truly significant or out of the ordinary. If one files a patent application on his development he will face this issue first in the Patent Office. Here, his counsel must prove to the patent examiner, an expert in his field, that the advance was not only new but sufficiently out of the ordinary to warrant the grant of a patent. Later, if the patent is litigated, he will probably face the same issues in court.

What Constitutes "Invention"?

Whether the intangible thing called "invention" is present in any particular advance is not easily determinable. While our present patent statutes attempt to define it in extremely broad terms, it is usually defined by what it is not. For example, an established negative rule of patentability makes it quite clear that it is not invention to add an extra part without producing some new function. Duplication, reversal or omission of parts and their function is not considered patentable invention, nor is mere change in size or substitution of one material for another. Other negative rules are also used at times.

Most plastics engineers have had occasion to check or review an issued patent. However, if one has had no patent experience, it is difficult to appraise such a document and determine what therein is important. While any comprehensive review of its contents is obviously beyond the present discussion, certain fundamentals and an understanding of the parts of the patent document can be outlined.

Starting from the first sheet, a patent often contains a drawing, executed in a form within strict rules of the Patent Office. If the advance is of mechanical nature, this drawing should disclose the structure of one or more

embodiments of the invention. It represents a quick way of checking various mechanical features of the disclosed invention.

The top of the first printed sheet gives data as to filing and issue dates, the name and address of the inventor or inventors, and a statement of ownership if the invention was assigned of record in the Patent Office before the patent issued.

There follows a general statement of the problem solved by the development, usually stated in part by generally-worded objects of the invention. A layman reading the patent should not interpret these broad statements as determining the scope of the protection accorded by the patent.

Following a brief reference to the various views of the drawing is a word description of the invention, usually cross-referenced to the drawing by numerals so that a reading of the description with a reference to the drawings should disclose the preferred embodiment of the invention, often with variations. This portion of the patent is the dictionary of the terms used in the all-important claims at the end of the document.

Making the Claims

The patent may be worthless or extremely valuable depending upon the wording of the numbered paragraphs called "claims." These claims define and limit the monopoly granted by the patent. Each should be considered separately. It is a "broad" claim if it contains no unnecessary limitations and thus can be read upon a maximum number of competitive variations. Every word is important in determining the scope of the monopoly. If you are reading a patent and find that all of the claims are burdened with a specified element which need not necessarily be used, the claim is said to be "narrow" or of limited scope. You will not infringe such a claim if you can manufacture the device without using such an element. However, if what you make appears to fall within the definitions of one or more of the patent claims, you will infringe such claims if you proceed and if the court ultimately holds such claims are valid.

Remember that a patent does not give the right to manufacture the invention free of infringement of other patents. The Patent Office does not even look to the question of infringement in issuing a new patent. It is concerned only with the question whether the subject matter of the claims in an application is of sufficient novelty and significance to justify a new patent. A patent gives the right to exclude others from making, using or selling the claimed device for a limited term. It is considered a contract between the government and the inventor. In return for a full disclosure of an invention, the government gives the patentee the right thus to exclude others for a term of seventeen years from the grant of the patent, with the understanding that thereafter the invention shall become public property and shall be freely available to all members of the public.

Protection to Research

Patents are important to businesses because they protect research and development investments and prevent competitors from freely copying the results without themselves going to the considerable expense of actually investigating and designing the new item. Patents are valuable business assets, being often profitable through licensing or by limiting the activity of competitors until a market can be established. Patents are valuable also as business assets which can be sold alone or along with other assets should it be desired to sell the complete business. Frequently overlooked is the fact that patents are often of value in settling controversies with competitors through cross licensing agreements. They are also valuable in protecting against patenting by others of your own developments because your patent is available in the files of the Patent Office for citation against competitors who otherwise might obtain patents on devices which differed only insignificantly from yours.

The Inventor

Patents are important to the inventor or to the development group not only as a tribute or acknowledgment of work done but because of the honor, financial rewards or promotions that may reasonably be expected by the inventor. They are an incentive for achievement and also constitute a form of publication coming to the attention of others in the same industry to evidence the versatility and ingenuity of the inventor.

To investors, patents are of importance in encouraging and justifying venture capital. In the absence of patent protection, many small businesses would never have been able to start or survive.

Procedures in obtaining a patent are complex and often difficult for the engineer to understand. Unless he has had much experience in the field, he will desire to consult counsel specializing in this practice. More than likely, such counsel will be found to have an engineering background as well as a training in law. The value of the patent will often depend upon the understanding, ingenuity and analytical ability of counsel.

What To Tell The Lawyer

The invention should be fully disclosed to your patent counsel. Tell him too much, rather than too little. A written description and sketches will be helpful in explaining your ideas and in facilitating his initial understanding thereof. Models are also helpful but are not essential. Tell him what is already old and outline features of your invention which you think are new.

You may be quite certain that nothing like your improvement has ever been on the market, but don't assume that your counsel distrusts your judgment if he suggests that a preliminary search of the patent records would be desirable. Many things appear in issued patents which have never reached the market and such patents are publications available to the patent examiner to deny you a patent on your advance or to limit your patent to some distinguishing feature or features. Of course, the Patent Office examiner will conduct the ultimate search and the results thereof will determine whether a patent is granted. Nevertheless, a preliminary search may save a considerable amount of money if the invention turns out to be old. Preliminary searches should be made in the files of the Patent Office because only there is there an intricately indexed and classified grouping of related patents and publications.

The Patent Office

After the patent application is prepared and sworn to by the inventor, it is forwarded to the Patent Office with a government fee of $30.00 or more. It is there given a serial number and is assigned to a particular division where it must await its turn for examination. Depending on the work load of the examiner, it may take from two to eighteen months, sometimes even more, before it is reached for action. The examiner then makes a search of the well-classified files available to him and cites any prior patents or publications he finds pertinent to the claimed invention. It is not uncommon for most or all of the claims of any reasonably broad scope to be rejected

(Please turn to page 64)

Reinforced Laminates for High Temperature Use

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. . . plastics suitable for high temperature use include phenolics, silicones and epoxies. Best results are due to judicious selection of resin and filler . . . and special attention to methods of cure . . .

REINFORCED PLASTIC LAMINATES for high temperature service can be made using both wet layup and "B" stage preimpregnated glass fabrics. The wet layup systems are high temperature polyesters (triallyl cyanurate-(TAC-modified)) and some special epoxy formulations (Epon 828/CL catalyst and some newer ones). However, these systems are inferior to the phenolics, silicones, and some very recent epoxy resins when exposures of 500°F and higher are considered. Of necessity the phenolics and silicones must be impregnated and predried (or "B" staged) before molding into finished form. As a result, it will be the "B" stage preimpregnated materials that will satisfy the higher and higher temperature requirements for the next few years. It is the purpose of this paper to discuss some of the recent developments in the low pressure resin impregnated glass fabric field and their effects on present and future high temperature requirements.

Table I lists a comparison of some of the physical properties of the various systems. In general, these systems can be divided into three classifications for design considerations: high strengths for relatively short exposures to high temperatures and fair electrical properties (phenolics); the same except with better electrical properties, similar to polyesters (epoxies); and lower strengths but the best electrical and the best for long exposure to high temperatures (silicones). There are other factors that designer must take into consideration, such as rain erosion, production of thick laminates, creep failure, temperature shock, reaction to extreme temperatures up to 5000°F for very short periods, gas permeability, flame retardancy or self-extinguishing characteristics, thermal conductivity and diffusivity and cost.

Prefinishes:

The development of a temperature resistant resin-glass combination will, of necessity, be influenced by the

Table I

Comparison of Various Resin Systems Applied to Cloth Style 1P81

	Phenolic	Silicone	Modified Epoxy
Flexural Strength (psi)			
(room temp.) dry	72,000	42,000	85,000
wet	70,000	33,500	70,000
Flexural strength (psi)			
at 300°F after ½-hr.	–	–	50,000
at 500°F after ½-hr.	55,000	15–20,000	35,000
at 500°F after 100 hrs.	15–42,000	18,000,	–
at 500°F after 200 hrs.	–	19,000	35,000
at 900°F after 2 hrs.	–	14,000	–
Tensile Strength (psi)			
(room temp.)	47,500	35,000	59,200
at 500°F	46,700	30,000	–
Compressive			
(room temp.) dry	50,000	27,000	65,000
wet	38,000	22,000	60,000
Modulus			
(room temp.) (psi)	3.2×10^6	2.8×10^6	3.5×10^6

type of bond of resin to glass. The better the bond, the higher the strengths, especially at elevated temperatures. The stability of the finish and of the bond to glass or resin may be influenced by temperature. Experience has shown that the idea of a Universal Finish is a false one, especially when abnormal temperatures are encountered. The original finishes were designed for polyester glass combinations, and because the chemistry of the polymerization of the polyesters is different than for the silicones, phenolics, and epoxies, it is reasonable to assume that one finish will not be the optimum for all resins. The silanes, for example, exhibit excellent bonding to the negative glass fiber surface through a siloxanol condensation (Si-O-Si). Starting from this point it is then possible to tailor the organic portion of the finish so that it will react strongly with the epoxies, silicones, and phenolics; e.g. a primary amine (Finish F40)* for reactions with epoxies, and olefinic groups for reaction with phenolics. The same may be true with the silicones. Recent prefinishes that appear very encouraging for high temperature resins are Linde A1100 and F40* for phenolics, NOL-24**, Linde A1100, and F40 for epoxies, and Dow Corning's T-31 and some silanes for silicones. At present, phenolics and epoxies are generally supplied on Volan A and A-1100 commercially treated cloth and the silicones on heat cleaned cloth; but the other finishes mentioned above are being investigated very intensively for high temperature applications.

Phenolics

There are basically three reasons why phenolic laminates fail when exposed to high temperature. These are oxidation of the resin or finishing agent, expansion of entrapped gases, and thermal degradation of the resin or finishing agent.

The first two can be controlled in part by the impregnator and laminator. The third is a function of the basic chemistry of the organic resin and there is little hope that organics will not be degraded materially by temperatures of 1000°F or higher. This potential limit can only be surpassed by research into new materials, basically inorganic, such as ceramics. The effect of oxidation has been examined with some startling results. A series of phenolic laminates were made and tested at 500°F after exposure of 100 hours in both a nitrogen and an oxygen atmosphere. The flexural strengths in the nitrogen atmosphere were about twice that in the presence of pure oxygen. This information has been confirmed by the use of special protective coatings that excluded oxygen from the laminate during the test. It is theorized the oxygen enters the laminate by capillarity through the fibers, as well as through the porosity network that is inherent with phenolic laminates. The possible use of antioxidants is being investigated at this time. Standard antioxidant materials appear to volatilize out of the laminate. Anything that can be done to decrease this oxidation effect will possibly allow phenolics and epoxies to be exposed to temperatures up to 1000°F for extended periods of time with only reasonable decrease in strength.

The expansion of trapped gases and the associated stresses are problems associated with "B" stage phenolics and silicones since these cure by condensation reaction, wherein there is always a certain amount of volatile produced. This is not true in the case of polyesters and epoxies, since they are generally composed of 100% polymerizable solids that cure by addition rather than condensation. In the case of phenolics, for example, as much as 0.3 to 0.6 cubic feet of volatiles for each square foot of 1/8" laminate is produced during the final cure. This startling volume cannot be handled by just flow of resin. The problem of removing these volatile fractions (which are mostly water, with some solvent and unreacted phenol and formaldehyde) is especially important where high temperature exposure is encountered, and can be greatly minimized by the correct curing schedules.

Effect of Volatiles

The most commonly used molding procedures are vacuum bag and positive press. In both cases the resulting phenolic laminates must exhibit porosity, since volatiles are produced in appreciable quantities even after the initial thermosetting of the resin. The type of porosity, however, has a large effect on the heat resistance of the laminate. Consider the positive pressure—matched mold system. Here, some of the volatiles are trapped within the matrix if fully cured under pressure (say 30 minutes at 200 psi at 325°F) since it is physically impossible for all the volatiles to leave the laminate through the edges. If this "full cure" laminate were then exposed to an elevated temperature (500°F or higher), the entrapped volatiles will expand rapidly, resulting in damage to the laminate. This damage is sometimes visibly evidenced by blistering, delamination, and actual "exploding" of the laminate. Of course, laminates greater than 1/8" in thickness exhibit this phenomenon in even more pronounced fashion. However, the damage may be on a microscopic scale. Here the expansion of gases may cause local stress concentrations resulting in local damage. The sum total of these localized effects is markedly reduced strengths at the elevated temperatures with no apparent blistering or delamination. Still another effect of "full-cure" under full pressure is the setting up of stresses after gelation occurs and during the final cure. Exertion of pressure during this period does not allow for relaxation of stresses generated by thermal and physio-chemical changes, possibly resulting in localized stresses that are powerful enough to fracture the laminate microscopically and sometimes macroscopically.

Post-curing of the "full cure" laminates will help, but these time-temperature rates become exorbitant. Very long times at low temperatures are required to eliminate the gases via osmosis through the fully thermoset phenolic resin system, taking care to avoid too rapid expansion of the gases. In addition to postcure, "breathing" or "bumping" the laminate during the initial stages of the cure is commonly used in an attempt to "de-gas" the resin while it is still liquid. This is only partially effective, since a fair amount of gas is produced after gelation of the resin; and also, there is the danger of "bumping" the laminate too close to the gel point with the possibility of damaging or destroying the interlaminar bond.

The "Kiss Cure"

A simple procedure has been worked out which minimizes these volatile-removal problems. We have dubbed it the "kiss-cure" method and it is a modification of the "low temperature" curing system proposed by J. D. Flynt of Cincinnati Testing Laboratories. The "kiss-cure", in comparison to the "full-cure" procedure, is based on the principle of degassing the laminate under the relatively mild conditions of oven postcuring, where the gases will tend to be exuded by osmosis rapidly without the forming of a network of pores. The actual process involves applying the full pressure to the "B" stage layup at full temperature (325°F) until the gelation point is reached. This is usually 3 to 5 minutes for a 1/8" laminate with most phenolics. As soon as this gel point is reached, a reduction (not release) of pressure is recommended to continue the

* *Coast Manufacturing & Supply Company*
** *Naval Ordnance Laboratory experimental finish*

cure a few minutes beyond the gel point. This establishes the laminate matrix, which should have enough integrity to be removed from the press and subsequently postcured. The reduction in pressure (down to 15 psi) essentially relieves the stresses that are usually set up during the thermosetting of the resin under high pressure, as well as encouraging the release of some volatile fractions. Subsequent oven postcuring, using low temperatures initially, and high temperatures as the curing progresses, eliminates the volatile matter as it is produced. This release is at a rate that may produce a network of pores that may present more area for attack by oxygen, but at a rate that will not set up stresses in the laminate. This gentle curing also helps to relieve any internal stresses that may have built up during the press cure. One of the big advantages of the "kiss-cure" cycle is the short time in press, allowing for high production rates.

The following is a typical "kiss-cure" cycle for 1/8" panels:

Enter press at 325°F and immediately apply pressure of 50-200 psi. Hold for 3-5 minutes (until gelation or no visible flow of resin takes place). Then reduce pressure to 15 psi and hold for 5-10 minutes to insure initial thermosetting of the resin. Total time in press is 8-15 minutes. Remove from press (if possible, press should be cooled prior to removal to avoid warpage resulting from thermal shock) and oven postcure for 10 hours at 250°F, 10 hours at 300°F, 10 hours at 350°F and 5 hours at 400°F. The resulting laminate should be very dense with almost no trapped volatile matter, and can be subjected to thermal soak at 500°F to 800°F with no delamination or blistering.

Effect of Postcure

An extensive study of the effect of the postcure cycle was made with the following results. There is no advantage gained by exposing or conditioning laminates during post cure to the test temperature (e.g. 500°F). In fact, a slight drop off in flexural strength was noticed when post curing was extended much beyond 350°F. However, a recent study by Beno, Smith and Dowell of Hughes Aircraft Co.* indicates that phenolic-glass (or any thermoset-glass) laminates, "when simultaneously subjected to loading and rapid temperature rise, exhibit plastic deformation at temperatures at or above those of postcure." This effect can be eliminated by including in the postcure cycle exposure to temperatures that will be encountered by the part during use. This exposure to, say 500°F, can be short and still be effective.

Reducing the post cure time at the various temperatures will reduce physical properties at elevated temperatures by a small percentage. However, reducing the postcure time to a bare minimum will reduce strengths as much as 10% and increase the tendency to blister on exposure to elevated temperatures. Where laminate thickness exceeds $\frac{1}{8}$", correspondingly longer post cure time is required. A recent study of $\frac{1}{2}$" thick laminates that had to withstand exposure to 500°F for 8 hours indicated that for this type of exposure a porous laminate is necessary.

To do this, a modified "kiss-cure" was used, as follows:

CURE
Time in Press—15 minutes
Pressure—15 psi
Temperature—325°F

POSTCURE
10 hours at 250°F
10 hours at 300°F
30 hours at 350°F

The reduced pressure encourages the formation of a network of voids, and the extended postcure ensures complete removal from the thick laminate. But this will, of course, result in some reduction of strength. It is possible to make this thick laminate using a 3 or 4 step process with curing and postcuring of 1/8" laminate increments in each stage.

Vacuum bag curing of phenolics is a somewhat different story. Here the volatiles are withdrawn by the vacuum while the resin is liquid and the pressures are low enough so that entrapment of gases under high pressure is minimized. It is impossible to avoid high porosity with vacuum bag laminates, but the effect can be minimized by use of a longer, lower temperature, curing cycle. This, in effect, removes gases at a rate approximating their production in the laminates and probably encourages their passage by osmosis. It also reduces the tendency for blistering or delamination during curing, since it allows escape of gases over a much larger area (all surfaces exposed) than is true with press cured laminates. The effect of a postcure is much less pronounced here than with the press cured laminates but does have some effect. As a result, the following typical cycle is recommended:

CURE
1 hour at 200°F
1 hour at 250°F
1 hour at 300°F

POSTCURE
5 hours at 250°F
5 hours at 300°F
5 hours at 350°F

Vacuum bag laminates are actually equivalent in strength properties to any positive press cure at equivalent pressures or pressures up to 50 psi. However, the modulus of elasticity of vacuum bag laminates generally runs lower than press cured specimens, and this is one of the most important design variables. Still further, erosion of vacuum bag laminates is generally higher than their press cured brothers and particularly the "kiss-cured" specimens. "Kiss-cure" generally results in smooth surfaces which should resist erosion more so than pore-filled surfaces. One of the biggest problems with vacuum bag laminates is the possibility of blocking of the bleeder cloth with excess resin causing reduction in pressure at that point. The result is a part with low strength sections in the laminate that may go unnoticed. Adequate bleeder cloth, the use of "B" stage materials with the correct flow, and possibly using a second vacuum bag encasing the entire layup will reduce or eliminate this possibility.

The final resin content of the phenolic laminate will definitely affect its high temperature resistance. Resin contents in the range of 26 to 35% will result in good strengths, but above 35% as well as below 25% as much as 15% to 20% decrease in high temperature strength can be expected. This resin content can be controlled by either the impregnator or the laminator by controlling the flow of resin during cure. From the above it can be concluded that a laminate is as good as the curing cycle used to manufacture it.

New resins and modifications are continually being evaluated for higher temperature exposure, lower thermal conductivity, etc. In particular, a new, modified phenolic resin was developed that evidenced reduced thermal conductivity at very high temperatures (F120-55) for air-

*SPI, Atlantic City, 1956

craft and rocket applications, where transient heat conditions exist, the thermal diffusivity is of great importance.

$$\text{Thermal Diffusivity} = \frac{\text{(Conductivity)}}{\text{(Density) (Specific Heat)}}$$

With reduced conductivity, increased density, and increased specific heat, the diffusivity for this new system has been decreased as much as 30%. This, combined with better erosion resistance, makes this material outstanding for short time exposure to temperatures up to 5000°F. Much work is being done to study the effect of phase changes at various temperature levels of phenolic-glass-filler systems in an attempt to decrease the overall thermal conductivity.

In general, the activity to develop new resin-filler, modifier-reinforcement systems for exposure to temperatures in excess of 1000°F is quite extensive.

Silicone Laminates

The silicones are of great interest because of their excellent electrical properties, resistance to high temperatures for long periods of time, and their chemical inertness. But many problems are associated with the production of good silicone—glass laminates. Silicones cure through a condensation reaction similar to phenolics, with the production of volatile materials. However, these volatiles do not present as much of a problem since they flash off more rapidly than phenolics, and the cured silicone resin is more porous than the phenolic. Recent investigations of effects of catalyst concentration, pH of glass surface, resin content of finished laminate, and amount of "B" stage or advancement of the resin prior to molding have shown that there is an optimum point for each of the above if satisfactory results are to be obtained. The impregnators must be aware of this and control their processing accordingly. For example, a neutral pH fabric must be used if consistency and higher strengths are to be obtained. Also, the optimum resin content in a finished laminate should be 28-32% for high strength, and 35-40% for best electrical results and nonporosity.

Because of the generally short gel time (1½-3 min. @ 350°F), laminating techniques are critical. Curing temperatures of 325°F to 350°F have been found to be the best. A precure is usually required to control flow and decrease volatiles. This precure is generally about 60 seconds at no pressure. Care must be taken not to exceed the gel point of the resin during the precure. Vacuum bag laminating is relatively simple and results in consistent parts.

Silicone laminates, when exposed to high temperatures, exhibit a high degree of gas permeability. This factor is especially important for hot-air ducting applications. To decrease this porosity, there have been four approaches used. They are:

1. Use of more layers of thinner fabric.
2. Use of slush coatings applied to the molded duct.
3. Use of a barrier sheet as an integral part of the laminate.
4. Use of higher resin content cloth.

The first method has not proven successful. For a given thickness, a larger number of glass layers, or a more closely woven fabric, only decreases the porosity slightly. The second approach has been studied extensively, with minor success. Silicone varnishes and rubber dispersions can be used to seal ducts. However, two or more coats are generally required and, depending on the material, special drying and curing times are required. In general, surface coatings at elevated temperatures do not exhibit good bonding to the laminate when stressed physically or by thermal shock. The third method results in the lowest porosity, but generally results in much weaker parts, with very low modulus ratings. By far the most successful is simply increased resin content of the finished laminate. While strengths are slightly reduced, the porosity is greatly reduced, with the modulus barely affected. A final resin content of 35-40% is considered best for reduced porosity at this time.

Two new silicone resins F131 *(D.C. 7141) and F132* (Bakelite GLSA-5973) has been developed primarily for vacuum bag work.

In "B" stage preimpregnated form, they result in increased tack and drapability over the more commonly used DC2106 (F-130) type. This is of definite aid for hand layup work, which has been a major problem to date. The tack and drape are also maintained over a longer period of time than present systems. The major drawback of these new systems are their reduced strengths at elevated temperatures.

Table II

	DC2106 (F-130)	F-131, F-132
Flexural strength		
@ R. T.	42,000 psi	44,000 psi
@ 500° F (½ hr.)	18,000 psi	13,000 psi

In spite of this, these new systems should open up new, low-pressure applications for silicone.

Epoxy

The new epoxy resins have found many applications in printed circuitry, tooling, aircraft parts, ducts, and other structural members where its unique properties are used to advantage. These materials exhibit relatively low shrinkage characteristics during polymerization (2% compared to 4 to 8% for most polyesters); excellent mechanical, electrical and chemical resistance properties; best of the thermosets for fatigue and erosion resistance; very low moisture absorption; excellent bonding to diverse materials, and excellent dimensional stability. While most of the applications for epoxy resins utilize the wet layup procedures that are quite familiar to polyester fabricators, "B" stage preimpregnated glass fabrics are coming into their own. While the epoxy resins are more expensive than phenolics or polyesters, in impregnated form the price differentials are negligible. In "B" stage form, the epoxies can be tailored to give high or low flow, variable drape and tack, and other handling properties that are desirable for specific applications. But one of the biggest disadvantages of the epoxies, in general, is their low heat distortion point. Some new developments, especially in "B" stage form, give promise of changing this picture.

When we talk about high temperatures with epoxies we generally mean temperatures of 300°F or so, in contrast to phenolics and silicones of 500°F and higher. However, some new experimental systems have raised the feasible temperature exposure from 300°F maximum to 500°F for as long as 200 hours; and possibly even higher temperatures are not out of the question. For an illustration of this, see Table III. For comparison purposes, Epon 828 CL (which is a well known 300°F temperature resistant epoxy system) was included.

*Coast Mfg. & Supply Co., Livermore, Calif.

Table III

New Impregnated Glass High Temperature Resistant Epoxy System (181 - Volan A Cloth)

System Number	1 828/CL	2 PMDA**	3 PMDA/ MA**	4 F160-14***	MIL-R-9300
Flexural strength (psi)					
at room temperature—dry	84,000*	81,800	54,100	86,800	70,000
wet	84,000*	–	–	70,100	65,000
at 300°F after ½-hr. exposure	48,000*	56,100	47,500	–	–
at 500°F after ½-hr. exposure	12,000	42,800	8,700	35,100	22,000
at 500°F after 200 hrs. exposure	–	–	–	36,800	18,000
Flexural Modulus (psi)					
at room temperature	3.7×10^6*	–	–	3.54×10^6	3.2×10^6
at 500°F after ½-hr. exposure	–	–	–	2.5×10^5	2.0×10^5
Compressive Strength (psi)					
at room temperature—dry	–	–	–	65,900	50,000
wet	–	–	–	60,200	45,000

* *Shell Chemical Co, data — 25 psi*
** *E. I. DuPont & Co.*
*** *Coast Manufacturing & Supply Co.*

From Table III it can be seen that F160-14 is far better than the 828/cl system, but this falls down somewhat on inter-laminar bond strength. The PMDA hardener system results in excellent short-time strengths @ 500°F, but appears to fall down when exposed for long periods. In addition, this system has poor shelf life (a few days at room temperature). The addition of maleic anhydride (MA) increases shelf life somewhat, but decreases temperature resistance. By far the best system is the F160-14 for high strength applications at elevated temperatures, and has good shelf-life (about 3 months). Other hardener systems, as well as resins and modifications are being continually evaluated to increase the heat resistance of epoxy systems. It is becoming feasible to design an epoxy preimpregnated system for particular service requirements over a wide range. The advances made recently in the high temperature resistance of epoxy resins, fortified with the inherent advantages of supply in "B" stage impregnated form, will open up new applications for these systems and should enable designers to use the electrical and other properties of epoxies to advantage at higher temperature levels.

Chopped Impregnated Fabrics:

In positive press molding, where the die configuration is such that impregnated fabrics can not be used, a premix or chopped roving system must be resorted to. However, the disadvantages of these materials are the low strength and the generally poor prefinish on the glass compared to aircraft grade prefinishes available on glass fabrics. In fabric form, the original sizing can be completely removed and the aircraft grade prefinishes applied under controlled conditions. The prefinishes for premix and roving materials, in contrast, are generally considered to be inferior to aircraft grade prefinished fabrics. These problems are generally not critical for general purpose requirements, but when exposures to high temperatures are involved, optimum properties cannot be obtained. To bridge the gap, chopped impregnated fabrics were developed. This is produced by chopping into squares or rectangles as small as ½" x ½", the phenolic, silicone, and epoxy materials designed for high temperature exposures. The impregnator can choose the fabric and control his processing so that high flow of both glass and resin results.

Some of the characteristics of this family of molding materials are:

1. Very high glass contents (70% glass or better).
2. Glass treated with high grade finishes designed for each resin system.
3. Available with resin systems designed for excellent mechanical, electrical, and thermal properties.
4. Supplied with resin systems not normally available in molding material form (heat resistant systems).
5. High flow characteristics resulting in excellent distribution of resin and glass throughout part.
6. Little tendency to "stack" chopped squares.
7. Can be utilized with standard compression and transfer molding techniques.
8. Can be molded using relatively low pressures (500 psi or higher).

With these materials now available commercially, the designers have another tool for satisfying unusual part shapes with a variety of temperature resistant resin systems in chopped form.

Conclusion

Much has been done to upgrade "B" stage impregnated fabrics designed for high temperature service, both from the handling standpoint and the development of new prefinishes and resins, but much more work is required. It is vitally important that resin suppliers, impregnators, and the laminators and end-users work as a team to develop better, more consistent parts that will withstand exposure to ever-increasing temperatures. ★ ★

The Holofol Process

By Walter Opavsky

Walter Opavsky Laboratorium
Coburg 3, Germany

THE HOLOFOL tubing machine above is used for production of artificial sausage casings.

THE HOLOFOL PROCESS has come to be known as the unique and revolutionary manufacturing method for the production of **seamless** hollow articles out of

1) plastic material
2) cellulose derivatives
3) natural and synthetic rubber.

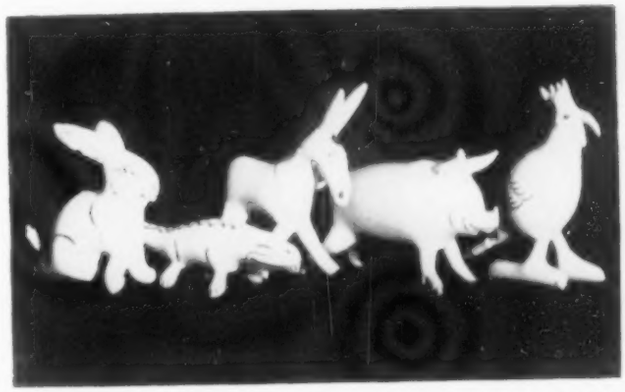
The principle of the Holofol process is based on the fact that foils or plates cut or stamped into shaped pieces may be processed into seamless hollow articles by a hardening of the surface, including the edges, which takes place from the outside towards the inside leaving, however, a thin unhardened corelayer.

This treatment is effected either by a physical or chemo-physical process, according to the desired finished article and the properties of the applied material.

After this treatment the core-zone, which has still its plastic character, is inflated by heating it in an infrared-zone, whereby a well-shaped seamless hollow body of high quality is brought about.

The process is already practically applied in Germany for the production of first class artificial sausage casings with universal properties, and of other sausage packagings, such as synthetic sausage bladders and sausage sacks.

Besides, this process is specially adapted to the manufacture of fingerstalls, surgeon's gloves, sanitary and technical gloves, as well as gloves for veterinary medicine.



PRODUCTS of the Holofol process are shown in the photographs above. A variety of Holofolized rubber articles are pictured at the top. In the center photo are seamless universal artificial sausage casings, bladders, and sausage sacks. Below are Holofolized inflatable toy animals.

MOLDING CYCLES

Edited by Louis Paggi, *E. I. du Pont de Nemours & Co., Inc.*

Warping of Molded Items

WHEN A MOLDED ITEM or section of an item bends or twists out of shape, or does not conform to the geometry of the cavity in which it was molded, it is considered to be warped. From the molder's point of view, the part has assumed an undesirable and unnatural shape. Considering the material itself, however, the item has merely assumed a "more natural shape" than that in which it was formed in the mold.

Exactly what takes place may be partly explained by the following examples.

1. If a hardened steel strip is bent as shown by the dotted line in Figure 1 then placed in a curved cavity, it will maintain its curved shape. The steel strip is now in a highly stressed state and will relieve itself and return to its natural state after it is ejected from the cavity.

2. If two straight and thin metal strips having dissimilar coefficients of thermal expansion are bonded together at room temperature, the resulting lamination will remain straight as long as the temperature to which it is exposed remains unchanged. If the ambient temperature is raised, the metal having the higher thermal expansion will grow in length to a greater degree than the lower expanding metal. Since both metals are firmly bonded together, no slippage can take place at the adjoining surface; therefore the lamination will bend in the direction of the lower expanding metal. If the ambient temperature is lowered below room temperature the lamination will bend toward the metal having the higher coefficient of thermal expansion. This principle is well known and used to advantage in thermostats and dial thermometers.

These examples, while not being exact analogies, are used merely to point out that the structure of a rigid or semi-rigid material can be deformed from its natural shape by applying force. As long as force is applied the deformed item will remain under stress and will only return to its natural form when the restraining force is removed.

Warping of molded items can be caused by more than one existing condition. However, the mechanics involved are the same regardless of the condition responsible. In every case it is the result of solidifying the item into a structure of non-uniform density thus setting up locked in stresses. A warped item can then be considered to have assumed its natural shape as determined by partial or complete relief of stresses.

There are three major causes of warpage in molded plastics, namely part design, mold design and molding conditions.

Warping Caused by Part Design

Figures 2 through 4 show parts having non-uniform cross-sections. These parts are likely to warp in the direction shown by the coarse broken lines to a degree depending on the following factors:

1. When the item is molded from a material having a high mold shrinkage, as for example polyethylene, warping may be greater than when the item is molded from a low mold shrinkage material such as acrylic resin.

2. When the gate is located in the thin section of the item, warping may be greater than when it is gated in the heavier section. This is because the thin section receives the benefit of higher pressure during set-up time whereas the feed to the heavier section is somewhat starved.

3. When the conditions used to mold are such as will yield the least overall mold shrinkage, warpage will be reduced. The reason why the molded items in Figures 2 through 4 warp may be exemplified by Figure 5.

Two bellows are fastened together, then the assembly is placed in a restraining frame. If the individual bellows are charged with differential pressure no noticeable change in the dimensions of the bellows will take place. However, when the bellows are removed from the frame the internal pressures will come to equilibrium and the assembly will bend in the

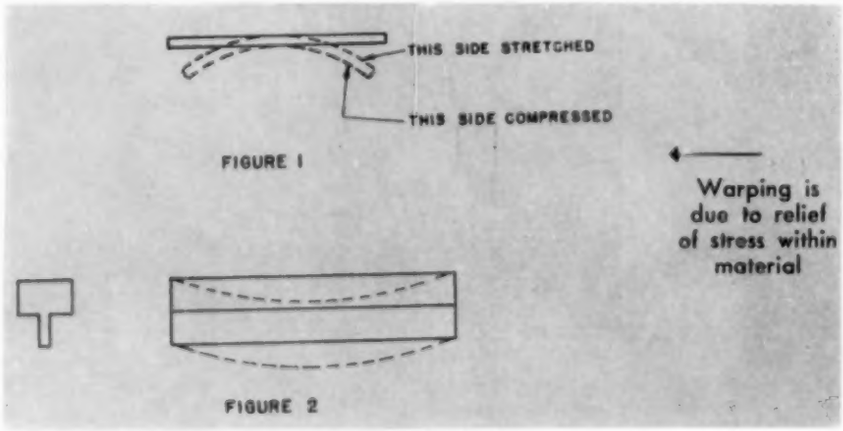


FIGURE 1

FIGURE 2

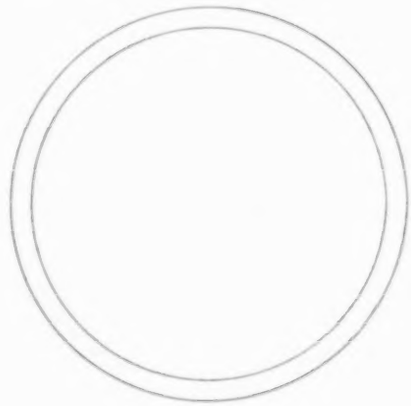


FIGURE 3

Warping can be expected when parts of unequal thickness are molded, due to differential stresses as illustrated at right and below.

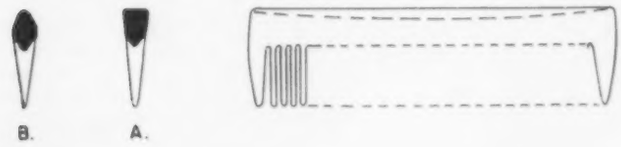


FIGURE 4

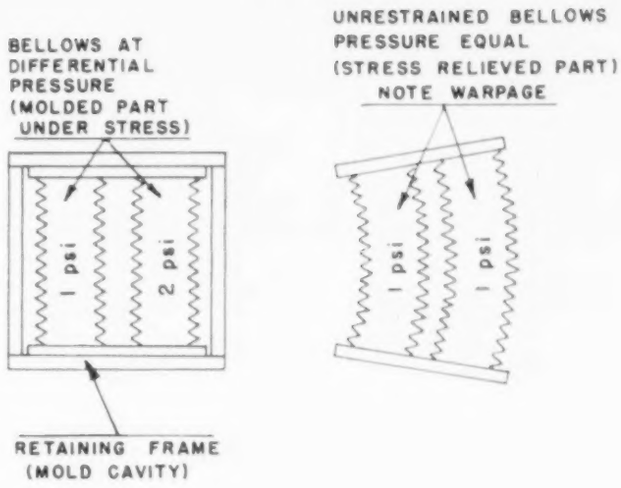


FIGURE 5

direction of the bellows previously charged with the lower pressure.

The behavior of the bellows above is analogous to what occurs in the molded items having dissimilar wall sections. As would be expected, the pressure within the cavity forming the item is at its highest point at the instant the mold is completely filled. This means that since the material making up the thin section will solidify before the material in the heavier section, the thin section will solidify under greater compression than the heavier section.

If two items of different wall sections are molded in the same mold and at the same time, the item with the heavier wall section can be expected to have a greater percentage of mold shrinkage than the thinner item. If the same two items are designed to form a single integral part, the properties of shrinkage of the different masses will remain the same, therefore, the greater wall section will pull on the thinner section thus causing the part to warp in the direction of the heavy wall.

The obvious correction to warpage caused by part design is to design with uniform wall sections, or as in the case of the rib on the comb (Figure 4B) to design with a symetrical wall section so that the force at one end of the cross-section is opposed by an equal force at the other end.

Warpage Due to Mold Design

When a mold is designed as shown in Figures 6 and 7 warpage due to a difference in heat dissipation of the two surfaces may result. Of the two, the arrangement shown in Figure 6 is likely to be the most troublesome. This is because the rate of heat dissipation through beryllium-copper alloy is several times greater than through steel. When this condition exists the surface of the item in contact with the beryllium-copper cavity will set up at a faster rate and to a lower temperature than the opposite surface.

The resulting difference in density causing warpage is due to solidifying the item with one surface contracting at a faster rate and to a higher degree than the other surface. In a sense, this type of warpage may be considered to be caused by stresses under tension which when relieved will cause the part to assume the desired shape. While in the case of an item with a combination of thin and thick walls, the warpage may be considered to be caused by stresses under compression which when relieved will

(Please turn to page 51)

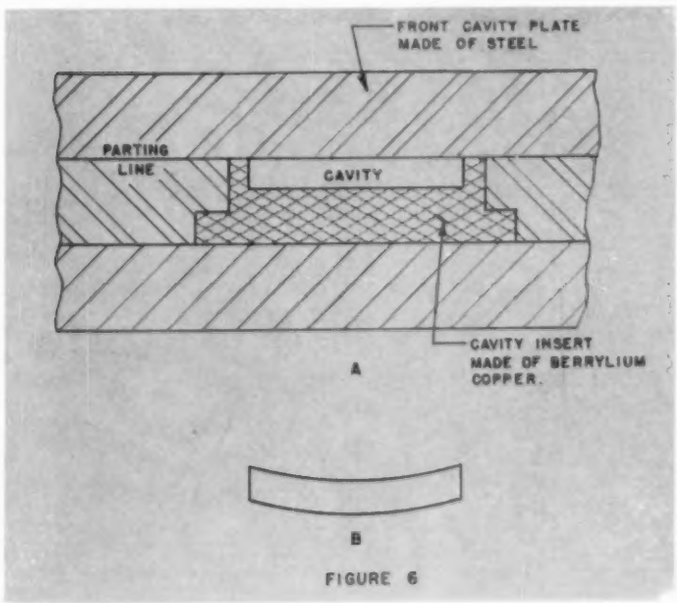


FIGURE 6

Design of mold may provide different rates of cooling at different areas of molded part and cause warping.

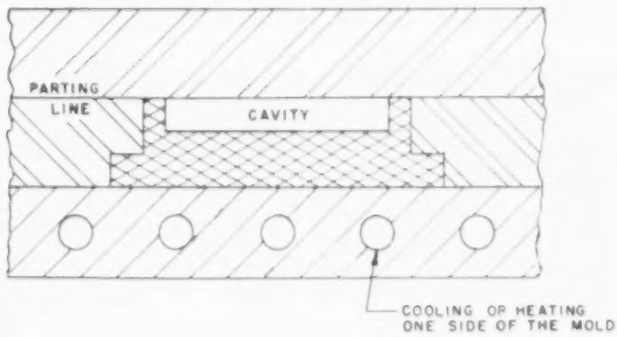


FIGURE 7

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
Monsanto Chemical Company
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Screw Cooling in the Operation of Single Screw Extrusion Machines

Imperial Chemical Industries, Ltd.
Plastics Division

THE design feature of the plastics extrusion machine which makes it differ from previous extruders has been the introduction of a system of cooling the extruder screw. This is usually carried out by internally coring the screw by drilling along the axis and sealing the core at the forward end of the screw. A stream of water is then directed along the core by one system or another. Such systems have been found to increase the mixing action of the screw and to give greater control of the extrudate.

Cooling Methods

Various methods of screw cooling are at present used. In some cases these have been provided by the extruder manufacturer, in others they are the result of a preference on the part of the operator.

The series of experiments described in this note was carried out to assess the merits of various screw cooling systems. The investigation covered a narrow field in that the performance of only one machine and one screw with two "Welvic" compounds was studied. It is thought, however, that the results are of general interest to users of extrusion machines for thermoplastics.

"Welvic" p.v.c. G3 6 and G4 7 (general purpose extrusion compositions) natural compounds coloured by masterbatch inclusion were used for the assessment. The masterbatches were added to the natural compound by dry tumbling and the mix fed to the extruder hopper at room temperature.

The extrusion machine used was a standard commercial $2\frac{1}{2}$" model having a screw length of $27\frac{1}{2}$", constant pitch of 2.75" with the depth of flight decreasing from 13 32"-$\frac{1}{4}$" along its length and the extruder head was of conventional design. An internally ribbed die normally used for production of garden hose was selected for the trials. This type of die was used for the following reasons:

1. The section is typical of large scale production
2. Sections of this size or greater often give more trouble than smaller sections
3. The size of the section enables careful examination to be carried out
4. Lack of extrusion control shows up in irregularity of the ribbed lines and lack of mixing on the inner surface.

Conditions of temperature and speed were kept identical for each trial, the flow of water in the screw being adjusted to a constant temperature. The systems investigated are outlined below and illustrated in Figure 1.

Screw Cooling Methods

1. Water at mains temperature is circulated in the screw cooling core by entry along a pipe to a short distance from the front of the core. Water discharges from the end and passes back along the core.
2. The reverse of system (1), water is circulated up the core and discharges down the center pipe. A rotary gland is employed to obtain a water-tight seal.
3. As in system (1) water is taken along a central pipe, the end of the pipe is sealed and water discharged into the cooling core from a series of small holes drilled along the last eighteen inches of pipe.
4. The centre feed pipe is shortened to discharge into the cooling core at a point corresponding to the feed hopper section of the screw.
5. No method of screw cooling is used at all.

Results

The following table gives an analysis of the results obtained. Sections cut from the extrusions using compound G3/6 are shown in Figure 2. The finishes of the tubes give a comparison under the conditions of test described and do not necessarily represent the best which can be obtained either from the compounds examined or the machine used.

Conclusions

Examination of the results shows that under the conditions of test used, the system which gave the best result

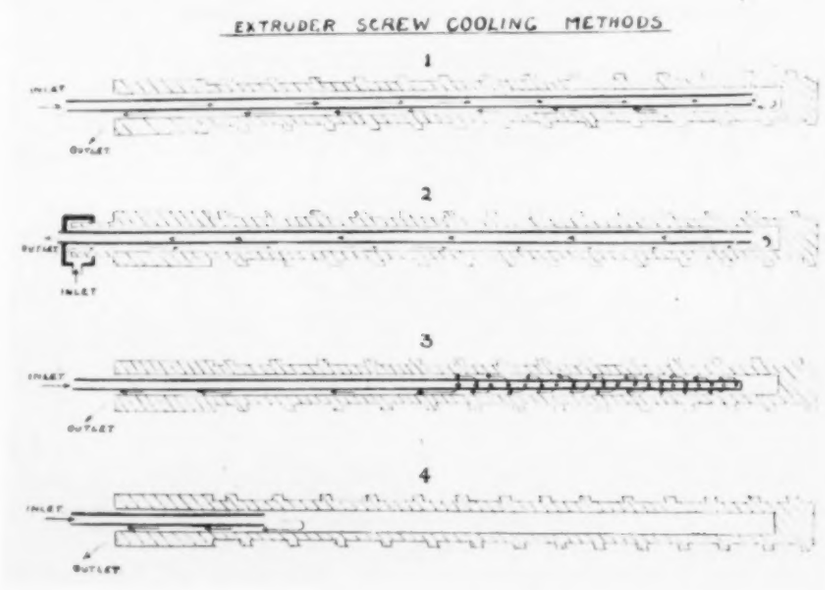

Figure 1. Four types of screw cooling used in this study.

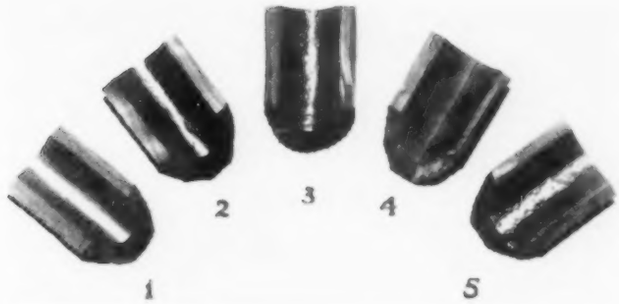

Figure 2 (left) Effect of screw cooling systems on color dispersion and internal surface.

Table I

Screw Cooling Method	"Welvic" P.V.C. Grade	Output Lbs/hr	Remarks
1	G3/6	23.8	Good extrusion. Colour well blended
2	G3/6	27.4	Fair extrusion. Colour fairly well blended
3	G3/6	29.4	Poor extrusion. Colour not mixed
4	G3/6	64.7	Very bad extrusion and colour mixing
5	G3/6	34.3	Poor extrusion. Colour not mixed
1	G4/7	25.7	Fair extrusion. Colour well blended
2	G4/7	27.0	Fair extrusion. Colour fairly well blended
3	G4/7	30.0	Poor extrusion. Colour fairly well blended
4	G4/7	40.3	Very bad extrusion and colour mixing
5	G4/7	35.1	Fair extrusion and colour blending.

(a) Screw Speed 30 r.p.m.
(b) Screw cooling water outlet temperature 35°C.

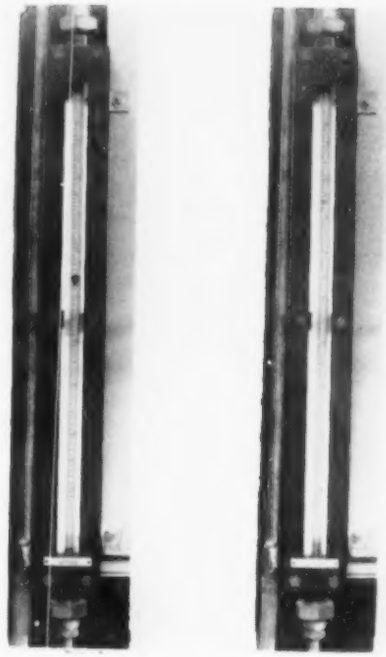

Figure 3 (above) Water gauge shows flow rate of cooling water.

(1) (assessed in terms of external and internal finish, colour blending, and consistency of section) also produced the lowest output.

It is reasonable to suppose therefore that a standard production extruder such as the one employed for these trials is incapable of supplying material to the extruder die in the right condition unless output is reduced.

An interesting feature was the increase in output resulting from screw cooling in the hopper section (4), but with corresponding lack of mixing and compounding.

The fact that a drilled pipe (3) gave inferior results to a pipe conducting water to the end of the bore (1) does indicate that the section of this screw requiring control is towards the tip. The partial freezing of material in the section of the screw flight restricts the movement of the unmixed lower layers of material, and the upper layers move forward.

The result of such a movement must be to create a higher rate of shear in the screw flight, probably comparable to the use of a high compression ratio. Without doubt this is one of the primary factors in mixing and fluxing of p.v.c. compounds in the screw flights.

The results obtained from system 2 were fairly good but the internal surfaces showed a lack of complete compounding; this again suggests when comparing the output figures that further control of the output was required to obtain the best results.

Screw cooling is obviously an advantage in the series of experiments carried out. Whilst it may not be necessary with all extruded sections to use cooling, extruders should be fitted with a good controlling method. The effect of under-cooling and over-cooling is so drastic in terms of extrudate control and output that knowledge of the amount of water supplied is an advantage.

A suitable type of water gauge is illustrated in Figure 3. This indicates the amount of water being applied to the screw. The use of such a gauge allows rapid adjustment of the cooling water flow to that necessary for the production of the best results.

Warping . . .

(Continued from page 49)

cause the part to warp into an undesired shape. Post heat-treating of items which may be warped due to mold design is generally beneficial whereas the same heat-treating of items warped due to part design will generally aggravate the condition.

The arrangement shown in Figure 7 will not be as serious as that in Figure 6 simply because steel is a relatively poor conductor of heat.

The elimination of warpage due to the above conditions can be accomplished by employing metals of uniform heat conductivity in both halves of the mold and installing mold coring in both halves of the mold, preferably the same distance from the cavity.

On the other hand warpage due to mold design may be used to advantage as shown by the broken lines in Figure 3. The back of the part, as in the case of a freezer container lid, may be made to "dome" or bend in the desired direction by use of differential mold temperature.

Occasionally we encounter warpage in a part of uniform wall thickness which will warp in spite of good mold design and control. This type of warpage is the result of over-packing or under-packing the core of the item or the area in the region of the gate. The mechanics involved here are similar to those employed in a pressure gauge using a Bourdon tube. If the cavity is visualized in the form of the letter "C" and is end gated, over-packing of the core of the item, such as may be accomplished by a delayed boost in pressure, may cause the molded item to warp outward. Underpacking of the cavity may cause the molded item to warp inward. Here again post heat treating of the molded item may correct the warpage. In items of this type however, if the gate is off center, over packing may occur as a result of linear flow along one plane. This type of over-packing is somewhat similar to that occurring in parts of dissimilar wall sections and as such may not be corrected by post heat treating.

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C. C. Winding
Cornell University, Ithaca, N. Y.

IN AN EFFORT to determine the status of instruction in the field of polymeric materials, three investigations have been made by the National Education Committee of the Society of Plastics Engineers, Inc. These surveys were made in 1951, 1953, and 1956. Questionnaires were circulated asking for information about offerings involving complete courses and also the amount of time devoted to polymeric materials in courses dealing primarily with other subjects. Basic courses in organic chemistry were excluded since it was assumed that such courses would include a small but variable amount of work on polymers and polymerization processes. A rather broad coverage was obtained since replies included courses on paints and varnishes, synthetic fibers, plastics, and rubbers. Such information was requested since it was felt that all courses relating to polymeric materials should be surveyed.

Broader Survey Basis

The first two questionnaires were sent only to universities having accredited curricula in chemical engineering and graduate programs leading to the Doctor's degree. This method of sampling was employed because such curricula give some indication of strong departments in both chemistry and engineering. The 1956 survey questionnaires were sent to all universities with accredited engineering curricula. Percentage returns were much better in the two earlier questionnaires since they were addressed directly to persons who had an interest in this field.

In order to put all the replies on the same basis, the amount of instruction offered by the institutions replying to the questionnaires was reduced to a semester credit hour basis. Normally, one semester credit hour indicates 15 hours of lectures and recitations, or a total of 30-45 hours of laboratory work. A considerable amount of estimation was necessary in evaluating the questionnaires but the relative order of magnitude of the amount of work offered is fairly accurate.

The following table summarizes the results obtained from all three questionnaires:

Summary of Replies to Questionnaires

Institutions	Number			Per Cent		
	'51	'53	'56	'51	'53	'56
Number of replies	37	55	65	—	—	—
More than 20 credits offered	4	4	3	11	7	5
Ten to 20 credits offered	5	5	8	14	9	12
Five to 10 credits offered	10	9	13	27	16	20
One to 5 credits offered	12	27	21	32	49	32
No courses in this field	6	10	19	16	18	29
Courses offered in Chemistry Department only	4	8	11	11	15	17
Courses available in Engineering Department	27	37	35	73	67	54
Total offering courses	31	45	46	84	81	71
Laboratory courses	21	20	17	57	36	26

Increasing the number of universities contacted apparently merely indicated that schools with strong chemistry and chemical engineering departments were more likely to offer instruction in polymeric materials. This would mean that although the number of replies received was such that we are a long way from complete coverage, any additional information that might be obtained would merely decrease the percentage of schools offering an appreciable amount of work in this field.

Levels of Instruction

The table indicates several levels of the amount of instruction offered. More than 20 credits would normally indicate an option or a major in polymeric materials for either graduate or undergraduate studies. There are probably four or five universities in this category but in at least two cases such courses are principally in the chemistry department and deal chiefly with polymer chemistry and other more theoretical aspects of polymerization reactions. Thus, it is evident that very few institutions are endeavoring to train engineers specifically for work in the plastics, rubber, and allied industries. There is, of course, a question as to whether or not such specialized work should ever be offered at the undergraduate level. Curricula are so crowded with courses involving fundamentals and work in the humanistic-social areas that very little time can be devoted to specialized instruction. Also, many of the larger industrial companies feel that such specialized instruction is done better by on-the-job training. Most of the more conservative universities have definite policies against specialized training. Such policies do not necessarily apply to graduate instruction at the Master's degree level. The SPE National Education Committee has proposed a specific program leading to a Master's degree for students wishing to enter the plastics industry.

Possible Expansions

Among the schools offering 10-20 credits in courses on polymeric materials, a few could readily expand the amount of instruction offered to provide a major or option in this field. However, such expansion would normally be rather expensive, particularly if laboratory equipment such as mills, mixers, or molding equipment had to be provided. The cost per student of such laboratories is very high and it is doubtful that they could be provided in private institutions without outside financial aid.

(Please turn to page 62)

Technical Committees' Reports

Editor: **Byron Nelson**

Professional Activities Groups

The Professional Activity Groups authorized by the National Council in January 1957 have been organized under the over-all direction of George W. Martin. Of the eleven P.A.G. committees presently authorized, six have been staffed and are working.

What is P.A.G.? What does it do?

Professional Activity Groups are individual National S.P.E. committees whose members have a common interest in a specific branch of the industry, such as compression molding, injection molding, extrusion, laminating, etc. These committees, individually called Professional Activity Groups, are collectively referred to as P.A.G.

Local Section Professional Activity Committees differ in that they may contain members of varying interests. Such committee members may at the same time be members of National Professional Activity Groups as described above.

How is P.A.G. Organized?

The P.A.G. Administrator appointed by the President with the approval of the Council, shall maintain and exercise complete control and direction of P.A.G. within the authority vested to the office by the Council.

Such Administrator shall be assisted in this office by an Assistant Administrator and such Liaison and Co-ordinating assistants as shall be deemed necessary.

Group Chairmen shall maintain control and direction of their group, assisted by a Vice-Chairman and a group Secretary. He shall appoint any Sub-Committee Chairmen as he shall deem necessary.

Section Professional Activity Committee Chairmen shall control and direct their committees and shall work in co-operation with P.A.G. through the Administrative Assistant responsible for P.A.G. co-ordination with section committees.

What is the Purpose of P.A.G.?

The purpose of P.A.G. is to further the progress, development, and enhancement of the Society and the industry by—

Working to develop engineering knowledge

Assisting in the dissemination of technical data

Co-operating with and working in an advisory capacity to all other committees and activities of the society.

Performing such research as possible that shall be necessary to resolve specific technical problems submitted

Performing any other duties that would foster each Group's interest and help to maintain proper balance in the activities of the Society.

All activities performed toward the accomplishment of these goals shall be done in such manner as to be in complete harmony with the objectives of the Society.

(*NOTE: This in its entirety is proposed as an addition to the Rules of the Constitution, pending Council approval*)

What are the P.A.G. Committees?

1. Extrusion
2. Compression Molding
3. Injection Molding
4. Laminating
5. Finishing
6. Plastics in Electrical Insulation
7. Casting (Non-Electrical)
8. Fabricating
9. Forming
10. Plastics in Building
11. Metals for Plastics Molds

(*NOTE: This in its entirety is proposed addition to the Rules of Constitution. Other committees to be added as required*)

Local Section Professional Activity Committees are also being organized and activated as rapidly as possible. Local sections are being urged to emphasize this activity. The overall P.A.G. organization is designed to effect maximum co-ordination between these local committees and P.A.G. at national level, which should result in maximum achievement.

The Professional Activities Group page in the Journal will be a permanent feature as a part of the Technical Committee's Report Section.

Our Technical Advisory Co-ordinator has his job well-organized and is ready, willing, and able to funnel al inquiries and problems into P.A.G. We hope that the membership will keep him very busy.

There is a general meeting of P.A.G. Group Chairmen planned for October. This will be an open meeting and all interested members will be invited to attend. Details regarding this meeting will be announced next month.

P.A.G. is ready now to accept any number of members wishing to sign up. Pick out the group of your interest. Join and let's get active. ★ ★

Plastics in Electrical Insulation

The Professional Activities Group on Plastics in Electrical Insulation has taken major steps in its growth and is fairly bursting with enthusiastic energy.

We held our first official, and highly successful, meeting on June 13 in Boston. The accomplishments of this meeting included the collective decision confirming the existence of need for this group, recognizing and outlining proposed tasks, organizing to work, and most important of all, meeting together and learning of our common problems and aspirations.

One of the questions which we all had before the meeting concerned itself with the need for such a group. After all, are there not a myriad of such groups already? Wouldn't we just be duplicating the work being done effectively by other groups such as the D-9 Committee of ASTM, AIEE, IRE, RETMA, and NEMA to name a few?

The answer is in terms of the *function* of the group. Each group functions from a particular point of view whether it be test methods, manufacturer's specifications or electronic packaging. But they all require the plastics engineer to supplement their work, be it to provide materials to test, products to require specifications or materials and/or methods with which to package. Thus, we, as plastics engineers, provide *raison d'etre* for the other groups to concern themselves with plastic materials. In addition, as a Professional Activity Group, we can provide co-operative research on problems which are of concern only to our own stratum of technical interests.

One example of the benefits of co-operative research is already evident from one of our task groups. The Task Group on Processing Methods for Encapsulating has started on a program on the explosive hazards of peroxides, has been offered the test facilities of a large national concern, and has been offered the co-operation of many others in the industry. Data has already been collected indicating techniques available for minimizing the hazards, much of which is based on materials which the suppliers felt were company confidential, but in fact were identical among those companies!

Another indication is my own brief experience as chairman of the task group on Dermatitis. Before I have been able to get the group together, I have been offered the full-co-operation (including the clinical data) from major resin and drug manufacturers.

The other task groups, no doubt, are experiencing the same enthusiasm. The group on Thermal Expansion and Crack Resistance has work all set out for it. The confusion of different commercial and military specifications on thermal tests requires this group to evaluate the various ones and to make suitable recommendations to ASTM. (This is the type of help ASTM seeks, by the way.) Each of the other groups has a similar "vacuum to fill".

Although our task groups seem to concern themselves primarily with encapsulation and printed circuitry, this does not imply limitation of scope, but rather, limited development. Electrical Insulations not only assume other forms such as film and wire coatings, and other methods such as extrusion and compression molding but may also, in the future, assume forms and methods presently undeveloped, or even unconceived.

If there are those within SPE who want to work in an area not mentioned, please let us hear from you. There is much work to be done in conjunction with the symposia, ANTEC's, RETEC's, and the other existing and future activities.

I know I speak for all P.A.G. Group Chairmen when I say—*we want you!*— P.A.G. is S.P.E. in action—You are S.P.E.—Why not contact us now and join a P.A.G. group of your specific interest?

Submitted by

Daniel I. Nitzberg
Chairman, Electrical Insulation Group

George W. Martin
SPE National Office
34 E. Putnam Ave.
Greenwich, Connecticut

I am interested in knowing more about PAG. Please send me information about

I would like to work on the _____ committee. Tell me how to join the national committee (or organize a local group).

Regional Technical Conferences

Hot Runner Molding

BUFFALO SECTION

September 27, 1957
Hotel Niagara, Niagara Falls, N.Y.

Four speakers will discuss four different phases of Hot Runner Molding. Further details and registration information may be obtained by writing:

Mr. R. W. Miller
3 Hillview Ct.
Lewiston, New York

Isocyanates

UPPER MIDWEST SECTION

October 8, 1957
Curtis Hotel, Minneapolis, Minn.

The Upper Midwest Section of the Society of Plastics Engineers is sponsoring an Isocyanate Symposium to be held Tuesday, October 8, 1957. The meeting will be held at the Curtis Hotel in Minneapolis, Minnesota between the hours of 9:00 A.M. and 4:30 P.M. Committee men in charge of the Symposium are, Paul Becker-General Chairman; Francis Brown-Program; William Everling-Publicity; Don Brekke-House; P. B. Herman-Preprints; Bill Brooks-Registration; and Cort Platt-Financial Secretary.

Serving as coatings, foams, adhesives and potting compounds to mention but a few applications; isocyanate based polymer are more firmly entrenched than ever as one of the continually growing family of plastic materials employed in present day industry. For further information and registration contact:

Mr. William Brooks
1139 Carl Street
St. Paul 9, Minnesota

Polyethylene

CLEVELAND-AKRON SECTION

October 17, 1957
Hotel Carter, Cleveland, Ohio

The morning sessions will cover four phases of material supply:

1. Survey of Polyethylene
2. Low density Polyethylene
3. Intermediate density Polyethylene
4. High density Polyethylene

The afternoon session topics pertaining to the processor and fabricator. For additional information and registration contact:

Mr. W. A. Messina
23817 Cliff Drive
Bay Village, Ohio

Plastics for Airborne Electronics

SOUTHERN CALIFORNIA SECTION

Hard working chairmen, Leo Costanza and Robert Steinman of the Southern California Section of the S.P.E., have announced an unusually instructive list of papers for their forthcoming RETEC on airborne electronics. While such a diversified program could be expected from the Los Angeles area, a center of airframe and guided missile research, it is noteworthy that the agenda includes men of national reputation. Subjects covered during the symposium will be:

1. "Effects of Hardeners on the Electrical Properties of Reinforced Epoxy Laminates"—R. M. Maybee
2. "Predication of Mechanical Properties Through the Determination of the Electrical Properties of Plastics"—J. Del Monte
3. "Electrical Properties of Plastics as Influenced by Cure Conditions"—J. J. Knudsen
4. "Dielectric Properties of Plastics—Controlled?"—Ed Burkart
5. "Urethane Coatings — Electrical Insulation" — Dr. M. E. Bailey
6. "Silicones in Electronic Systems"—K. H. Hoffman
7. "Encapsulations for Electronic Systems"—R. M. Houghton
8. "Polyurethanes in Electronic Systems"—Ben Carroll
9. "Plastic Coatings—Conductive and Insulating"—Albert Davis
10. "Printed Circuits"—Dr. L. H. Ott
11. "Plastics in Guided Missiles"—M. A. Nadler

In addition to the program above, there will be a luncheon address on "Plastics in the Earth's Satellite Project" which will be particularly informative and timely.

The symposium will be held on Monday, November 11th, at the Ambassador Hotel, 3400 Wilshire Boulevard, Los Angeles. Because of the length of the one-day program, the meeting will start promptly at 8:30 A.M., the committee has announced.

Any questions or correspondence concerning the symposium should be directed to—

Mr. Walter H. Kadlec
E. I. du Pont de Nemours & Co.
2930 East 44th Street
Los Angeles 58, California

The committee expects an extensive out-of-state registration.

NEWS of the industry

New Hercules Plant

Hercules Powder Company's new multimillion dollar plant to make a new type polyethylene plastic material, with 30,000,000 pounds per year capacity, is now ready for commercial production, the company announced today.

Located at Hercules' Parlin, New Jersey plant site, the plant is the first in the United States to employ the Ziegler process for the manufacture of a new plastic material that offers many advantages.

On hand to participate in the plant opening ceremonies was Professor Doctor Karl Ziegler, of the Max Planck Institute in West Germany, discoverer of the Ziegler process.

Cadillac-Dayton

The Dayton Rubber Company of Dayton, Ohio, and Cadillac Plastic and Chemical Company, Detroit, have completed a merger through an exchange of stock.

Cadillac Plastic will retain its corporate name and will continue to operate under its present management and personnel as a wholly independent subsidiary of Dayton Rubber. There will be no change in the subsidiary's operating policies.

Pre-Flocked Sheet

A versatile new plastic material has been developed by The Gilman Brothers Company of Gilman, Connecticut. Named Stylour, the new material is a pre-flocked plastic sheet for vacuum forming or trim use.

Custom Molding

Kimball Manufacturing Corporation, San Rafael, California, is now operating with new and enlarged facilities and greatly increased capacity which enable them to offer custom molding services to interested firms.

Plastics Bits

Router bits for tooling plastics, made of wear and abrasion-resistant "M-11" chrome cobalt steel, are described in 4-page Bulletin RB-56 by Detroit Tap & Tool Company, 8615 E. Eight Mile Road, Baseline, Michigan.

Included are specifications and prices for straight fluted bits from 1/16" to 2" diameter; spiral fluted bits from 1/8" to 3/4" diameter. All have straight shanks, with either single or double ends in some sizes.

Also listed are spiral fluted router bits with inverted taper shank, single or double fluted, in 5/16" and 21/64" diameters.

Dutch Trade Show

During the fall of 1957, the first Netherlands trade show of the plastics industry will be held in the R.A.I. exhibition building in Amsterdam. Exhibitors from many nations are expected to participate in the fair, technically known as the "Macroplastic", which is scheduled for the week of November 13-20.

Of some 107,600 square feet of floor space available to exhibitors, over half this space has already been rented, and is about equally divided between Dutch and foreign exhibitors. The leading foreign participator thus far is Germany, with Great Britan following closely in second place. A large space has been reserved by the British plastics industry for a collective booth set up under the auspices of the British Board of Trade.

Exhibition space in the fair is still available to U.S. producers.

U.S. dealers who desire further information about the plastics fair may contact the show management organization at the following address:

N.V. 't Raedthuys
Tesselschadestraat 5
Amsterdam-West
Holland
(Telephone 82814 - 86637)

Molybdenum Sulfide A Filler for Plastics

"Moly-Sulfide as a Filler" is the title of a new 4-page bulletin just issued by Climax Molybdenum Company, Dept. L, 500 Fifth Avenue, New York 36, N.Y. The bulletin describes the uses of Moly-Sulfide—a blue-gray powder, chemically known as molybdenum disulfide—as a filler in nylon, phenolic laminates, Teflon and other plastics, natural and synthetic rubber and asbestos, and outlines the preparation and properties of Moly-Sulfide-filled products as well as the properties of Moly-Sulfide itself. Copies of the Bulletin, designated LU-12, are available on request.

Acrylic Sheets

12-page bulletin contains complete information on handling, machining, forming, cementing and annealing of low-cost Cadco extruded acrylic sheets. Table of properties and four pages of light transmittance charts, including comparison with cast sheet. Cadillas Plastic & Chemical Co., 15111 Second, Detroit 3.

Men In The News

Henry J. O'Neil

Henry James O'Neil recently joined the Sales Staff of Thiokol Chemical Corporation as Technical Sales Representative. He will cover the Detroit area: Ohio, Michigan, and Indiana.

Ned W. Spangler

The appointment of Ned W. Spangler as manufacturing superintendent of the plastics plant of Sylvania Electric Products Inc. in Warren, Pa. has been announced.

Prior to his new assignment, Mr. Spangler was division industrial engineer in Warren. He joined the company in 1952 as an industrial engineer in the company's Parts Division metal stampings plant in York, Pa.

Frank W. Heidenreich

Frank W. Heidenreich has been named plant manager of the Resolite Corporation, Zelienople, Pa.

Heidenreich has been director of research and devolopment at Resolite for the past five years, and will continue to hold his research responsibilities in addition to his new duties of overall plant supervision. He has been instrumental in the development of many new fiberglass-plastic products and improved methods of manufacture.

Robert E. Burke

The appointment of Robert E. Burke as manager of the plastics plant of Sylvania Electric Products Inc. in Warren, Pa., has been announced.

A native of Buffalo, N.Y., Mr. Burke joined Sylvania in 1953 as a manufacturing superintendent in the company's Radio and Television Division. The following year he was appointed manufacturing superintendent of the company's plastics plant in Warren.

Prior to joining the Sylvania organization, Mr. Burke was with Trico Products Co. and Morrison Steel Products Co. in Buffalo.

Richard L. Rouviere

Richard L. Rouviere was recently appointed to the position of Market Extension Engineer by Devcon Corporation, Danvers, Mass. Rouviere will work with Devcon's industrial supply dealers in bringing newly developed technical applications for Devcon's Plastic Steel to industrial plants.

In-plant demonstrations showing new uses for Devcon's Plastic Steel for making plastic molds; duplicate patterns, match plates and core boxes in foundries; and building jigs and fixtures and dies for metal working shops will be conducted. A special slide film program is available for plant groups and technical society meetings.

AROUND THE WORLD

UNITED STATES

ELECTRICAL MANUFACTURING

May, 1957

Abstracter: Bennett Nathanson

Fluorinated Liquid Dielectric for Fixed Paper Capacitors — *Thomas D. Callinan and James B. Romans, U.S. Naval Research Laboratory*

Materials usable over a temperature range 65°C to 200°C have been developed from synthesis of partially fluorinated compounds. Properties of these materials and characteristics of impregnated capacitors are discussed in this report based on a Naval Research Laboratory program. Variations with temperature of the dielectric constant and the dielectric loss factor, variations with frequency of the dielectric constant and tangent of the loss angle, and variation with temperature of the capacitances and power factors are among the points explained and fully discussed.

FRANCE

'INDUSTRIE Des PLASTIQUES MODERNES

May, 1957

Abstracter: Hans Mayer

French Use of Plastics — *Jacques Cohette*

French production of plastic raw materials increased by 32% compared to 1955 while actually 36% more were consumed in 1956 than in the preceeding year. Since 1952 production of resins has increased by an average of 40% per year while consumption has increased by an average of 33% per year. On the basis of these figures and in view of anticipated developments production of resins and consumption should even out at the level of 500,000 tons by 1960.

Of the materials being produced in France the increase in production has been most outstanding in the field of polyester resins.

The Employment of Plastics in Military Procurement — *Kiger*

Discussed is the use of plastics in the non weapon field. The author differentiates between the field of subsistence which comprises the packing, preserving, and transporting of food, potables etc., and clothing including such items as helmet liners, protective vests etc. In this connection the needs as well as the test methods are described. It is interesting to note that the decision whether to use plastic materials for certain applications is not entirely determined by the outcome of tests and the question of costs. The national economy demands that existing industries like f.i. the leather industry must not be robbed of important outlets if the material can do the job satisfactorily, even at higher costs.

GERMANY

KUNSTSTOFFE

May, 1957

Abstracter: Anne Schwend

Latest Experience with Frictional Properties of Polyamides — H. R. Jacobi

With the help of a modified type of Almen-Tester as described by E. G. Ellis in Scientific Publications, 1953, the Almen-Wieland-Tester, the frictional and deformational properties of polyamide bearings and coated steel shafts as well as the degree of wear upon dry, wet and lubricated running were investigated. The influence of added molybdenum di-sulphide and graphite to polyamide 6, i.e. polycaprolactam, show that upon dry running MoS_2 bestows more favorable frictional qualities than graphite and vice versa a 10% addition of graphite is preferable if both bearing and shaft run in water. The effect of tempering and irradiation upon the surface structure and, hence, the frictional properties was thoroughly tested and found worthwhile. To eliminate this extra process upon injection molding "fine grain" polyamide 6 was molded at 140°C mold temperature. Favorable results may still be bettered through further research. The high deformation of polyamide 6 bearings was compensated by a permanent upsetting. Investigations shall be extended to other interesting types of polyamides.

Drives of Hydraulic Molding Presses — *J. Krause*

The peculiarities of both group and self-contained driving of molding presses by press water or oil are discussed.

Main Characteristics of a PVC Sheeting Calender — *P. Siegel*

Construction limits of calenders for PVC sheeting set by sagging and slant of rolls as well as even temperature distribution over length of rolls are aired.

Automatic Winding of Plastic Sheeting — *W. Schmitt*

An introduction to the principles of automatic winding is followed by a description of a machine built in accordance therewith.

Fundamentals in Kneading, Dispersing and Plasticizing — *J. Aeschbach*

Today's exigencies in the kneading, dispersing and plasticizing fields are discussed and details of typical examples cited.

Further Findings upon Extrusion with Hi-Speed Screws — Erich Beck

The main principles for increasing the volume output of relatively small single screw extruders—increase in revolutions per minute and control of the extrusion process via the viscosity of the melt as discussed in Kunststoffe 1956, pages 18/20—are completed by a description of a number of auxiliary equipment developed for the production of pipes and tubes, blown films, wires and monofilaments from thermoplastics. Theoretical data is compared with achieved results for screws of 18 to 35 mm in dia.

To extend the application of such principles also to those thermoplastics

which require processing at very high viscosities close to the maximum admissible temperature limit and realizing that an increase in the effective pumping degree would not be feasible with present screw designs, a new type of extruder with a screw dia. of 65 mm for an output of 60 kg/h. of high pressure polyethylene was developed. To influence the effective pumping action of the screw the following additional features were provided: 1—stepless change of the revolutions per minute between 150 and 700; 2—cooling device for screw and screw barrel; 3—exchangeability of the screw barrel within the working zone of the screw to keep the effective pumping action of the screw independent of the frictional value of the flowing material and the surface of the screw barrel; 4—an energy conversion zone following the end of the screw to homogenize eventually inhomogeneous parts of the melt conveyed by the screw in all those cases in which the afore-described measures permit a highly effective pumping action and, hence, low heating within the screw zone; 5—an extensometer for control of longitudinal forces during operation.

Further developments of Urea Formaldehyde Foams — *H. Baumann*

"Isoschaum" a urea formaldehyde foam by Badische Anilin & Soda-Fabriken with a practical heat conductivity of λ .025 x 1.06 = 0.04 kcal/mh°C and after drying of λ .025, a medium moisture content of 3%, a sound deadening degree of .71 to .85 at medium frequencies depending on weight per cubic metre, which latter may vary between 4 and 25 kg/cu.m. non-inflammable, with a temperature resistance up to 150°C., non-embrittling, resistant to benzene and benzol as well as organic solvents, but destroyable by highly concentrated acids and lyes, non-hygroscopical, holding a small amount of phosphoric acid as catalyzer for the protection of metals, may now be applied on the spot by a small portable foaming apparatus consisting of two containers hooked to a low pressure line. An extra-size foaming apparatus was developed for the mining industry. A description of these apparatuses and their functioning is followed by a survey on fields of application, i.e. the mining and building industries, power stations, insulation of gas pipe lines, heat insulation of tents, etc.

Plastics for Packaging of Foodstuff—*L. Robinson-Goernhardt*

Another contribution to the German law on foodstuff packaging under preparation, as to how relatively simple means permit an analysis of the attitude of packaging films towards foodstuff, in particular liquids, fats and oils. Solubility, volatility and migration of plasticizers of a PVC film of U.S. origin enjoying ever larger application and having great mechanical strength and density, were defined.

Granulating and Drying with the "Plastificator" by Werner & Pfleiderer — *Hugo Zoebelein*

To the normal plastificator as described previously, used for gelatination of plastics, has been added a granulator so that granules are now obtained from powder in one operation. The same machine has found advantageous use as dryer for thermoplastic polymers produced in accordance with the suspension method or for suspensions. However, materials to be dried should stand temperatures above the boiling point of the liquid to be evaporated. Materials with a high softening point are obtained in powdery form, those with a low softening point as strands which are cut into granules by a mill attached to the plastificator. Particularly favorable results were stated upon drying of Polyvinyl acetate pearl polymers which are produced as granules of less than .5% water content and show much better melting properties than normal pearl polymers.

Molding Presses for Glass Fibre Reinforced Casting Resins — *E. Witt*

An introduction into the technique of serial production of glass fibre reinforced articles is followed by a description of a molding press as built by Becker & van Huellen, which represents a self-contained oil-hydraulic unit. More than 50 units in operation testify for its excellent functioning. The chassis of a motor-cycle molded on such presses is cited as example.

Progress in Vacuum Forming of Thermoplastic Plates — *G. Matulat*

New methods developed during recent years such as the negative plug method and drape forming with pneumatic pre-stretching and the so-called pneumatic forming constituting an important supplement to straight vacuum forming have favorably contributed to the competitiveness and in some cases superiority of vacuum formed parts versus metal parts, a trend now rapidly gaining ground in Europe.

★

DER PLASTVERARBEITER

April, 1957

Abstracter: Leo Fischer

Some New Data on Characteristics and Physical Behavior of Polystyrene Foams — *Dr. Helmuth Osken*

This article describes the testing procedures with "Poresta," a styrene foam manufactured in Germany. An important factor in the physical quality of styrene foam is the cell structure, whether it is open or closed, as well as the thickness of the cell walls. The widest used foams weigh .015 grams per cu.cm. The compressive strength of this density foam is 1 kg. per sq. cm. The modulus of elasticity is 80 kg. per cm., which makes this foam extremely useful for acoustical purposes. It is stated that the modulus of elasticity is a measure of acoustical quality. A ready technique for measuring insulating value of foam is clearly described.

It is suggested that styrene foam be used for flooring and techniques are described measuring the dampening quality of a styrene foam insulating floor. Measurements and graphs indicating sound reduction of at least 50% are presented. It was found that styrene foams do not reduce echoes or reverberations, however. Foams with very small cells and great flexibility have proved of value in this respect, especially if the flexible foam sheet is nailed several inches from the wall.

Application of Electronic Sealing — *Walter Opavsky*

An electronic sealing machine, continuous and automatic, is described, especially in its application for producing hollow air filled articles.

Sintering of Thermoplastics—Thomas Engel

Sintering is an old art, especially in ceramics and powder metallurgy. In plastics the following lend themselves to sintering operations: Polyamides, polyethylene, polymethacrylate and polyacetobutyrate. Resins must be finely powdered. Polyethylene is pulverized at —100°C in liquid nitrogen. An extruder can also be used where the polyethylene is extruded in very fine film and broken up with a steam or air blast. Polyethylene can also be dissolved in hot trichlorethylene and precipitated in a very fine powder, which is then extracted and washed. The size of particles must not be greater than .4mm. The powder must have good flow properties. Fillers of various kinds can be added, but the filler particles must be smaller than the resin particles.

Molds of steel are heated to 200°C and dipped in the polyethylene powder and removed after a few minutes. The coated mold is then subjected to heat again for a few minutes. This process can be repeated to build up the desired thickness. Production of large pails, pipes and vessels are described. Completely sealed units, such as carboys, are made by tumbling. Four hundred gallon vessels have been produced with this technique. Tubs for the meat and fish industry are an especially wide market.

SECTION NEWS

Edited by
Charles P. O'Donnell
Monsanto Chemical Co.
Springfield, Massachusetts

New York

Automatic Molding Panel Discussion

Jim Dugan

Over 100 members and guests attended an April 10 meeting on "Automatic Molding," sponsored by SPE's New York Section. The locale was the Governor Clinton Hotel in New York City, and Saul Blitz, Tico Plastics, served as moderator.

John A. Kavanagh, Standard Tool Co., spoke on "Small-Size, Hot-Runner Molds," covering the advantages, disadvantages, and limitations of internal manifolds with respect to the molding of small parts. On the positive side, he cited material savings, deeper draw, faster cycles, and homogeneous castings; higher cost on the debit side.

Glen Bowers, Cambridge Panelyte Molded Plastics Co., discussed the "Use of Hot-Runner Blocks in Large Injection Molds." The block was defined as an extension of the heating cylinder, built as an integral part of the mold. Single-sprue, straight injection was found ineffective in the molding of 1,200-square inch parts since the shot failed to fill the cavity. In addition, a clamp pressure of 1,500 tons meant a clamp of about one ton per square inch; insufficient to keep the mold closed. A single-cavity, hot-runner mold with three sprues to the back side of the part was found to be very satisfactory. It offered an advantage over three-plate molding, since there was only one parting line instead of two. One caution—each sprue must have its own thermocouple.

Frank Bailey, Improved Machinery, Inc., spoke on "Multiple Nozzles," which permit gating directly into the cavity and eliminate sprues. This method could be described as external, hot-runner molding. Gate freezing can be corrected by removing the tip, thus reducing maintenance. There is a limitation, however, to 4-6 cavities.

Harvey Jensen, A. Schrader's Sons, division of Scoville Mfg. Co., Inc., discussed "Three-Plate Molding," which he felt offered technical advantages rather than reduced costs. The third plate is in the middle, and carries part of the cavities plus the runner system. Three-plate molding is said to minimize flow lines, as opposed to tunnel gating; prevent plugging of the gate; permit better gate design; allow easier changing of gates and runners; and give better separation of the finished part from the runner system.

May Meeting

The May 15 meeting of SPE's New York Section, also held at the Governor Clinton Hotel in New York City, featured a two-part program. About 80 members and guests were in attendance.

"Methylstyrene Molding Compounds" were explained by American Cyanamid's J. A. Melchore, who pointed out the heat-resistant characteristics of these recently-introduced materials. Other features claimed for the materials include their improved toughness; chemical, mar, and craze resistance; and their ease of molding around metal inserts. Methylstyrene (vinyl toluene) is available as ortho, meta, and para isomers, which can be combined to produce injection molding compounds with varying amounts of heat resistance.

Methylstyrene-acrylonitrile copolymers are obtainable also, and these materials show still better resistance to breakage, marring, crazing, and chemicals. Service temperature for the copolymer averages about 212° F., slightly less than that obtainable with the straight methylstyrene combinations.

"Moving More Merchandise Faster" was the topic of a talk by Joseph Broslaw, Ralf Shockey & Associates, Inc. He felt that "extra mileage" could be gotten out of existing advertising and selling by merchandising informative labeling. A recent survey indicated that informative labeling alone resulted in a retail-sales increase for plastic items in the neighborhood of 5-8%. Key to this success is the retailer, who is often so busy that he cannot take the time to explain the functions and limitations of his merchandise. This, too, is based upon the assumption he knows the answers.

Retailers are most interested in the possibilities of self-selection. Department stores carry anywhere from 20,000-100,000 items, depending upon the size of the store. Sales clerks, and even the small retailer, simply do not have the time to learn about these products.

Northern Indiana

'Automation' Final Meeting Topic

Leon J. Page

The final meeting of the Northern Indiana Section for the spring term of 1957 was held in the Oak Room of the Van Orman Hotel, Fort Wayne, Indiana, the second Tuesday of June.

As has been the custom through the years past, the wives of members and guests were entertained as special guests for the evening.

The organization will not hold a regular meeting again until September 10, 1957. The procedure of a summer recess in meetings is an established custom for the Northern Indiana Section. However, tentative plans for a summer meeting of informal nature were discussed and will be developed at a later date.

Mr. Carl Rinne, General Manager of the Specialty Transformer Division of the General Electric Co., Schenectady, New York, was the guest speaker of the evening. His topic of discussion was titled "Automation". The economic aspects of automation and its relation to the competitive marketing of products were dealt with quite thoroughly. The speaker carefully stressed the point that labor unions have nothing to fear from this method of production speedup in as much as the demand for goods will far outstrip the available labor force in the very near future. Also, the goods produced under automatic procedures will actually stimulate the consumer appetite for a more and more varied diet of products.

Mr. Rinne illustrated many points of his talk with a fine movie on this subject which was judged to be very interesting as well as informative.

The section presented a personal gift to each individual present. This gift was a billfold suitable for either pocket or purse and, naturally, was fabricated of plastic.

Detroit

Business Meeting, Dinner Dance Held To Entertain Wives

Mac Nichols

Under multi-colored lights on the sprawling veranda of the Hillside Golf and Country Club in nearby Mt. Clemens, the Detroit Section entertained their wives at a brief business meeting and dinner dance on June 21st.

The affair climaxed the end of the fiscal year for the Section's brilliant technical and social calendar under the direction of Jay Kuhn, the retiring president.

The group was given the opportunity to welcome the newly elected officers of the Detroit Section for the coming year.

"Colonel" John Slater of Eastman Chemical Products will take over the reins as President. He will be assisted by Vice Presidents, George Wadtke of Fabricon Products and Mac Nichols of Manco Products. Dick Oglesby of Rohm & Haas will serve as Worthy Scribe and Fred Zumstein of Fellows Gear Shaper will stand guard at the portals of the vault.

Gordon Thayer of Dow Chemical, Art Linzell of H.P.M., and George Wadtke of Fabricon Products were elected by the Section to the Board of Directors.

A note of depression was brought into the meeting when it was announced that Mary Denny had resigned as Recording Secretary of the Section—a post that she has most capably filled for many years. It is hoped that the present pressure of outside commitments will soon be alleviated to permit Mary to again take up her Pen and Scroll in our best interests.

The gay evening was enjoyed by approximately 70 guests who shuffled, strutted and stomped to the rhythmic rhythms of "Ponchito and his Scintillating Swedes" whose repertoire ranged from Minuets and Waltzes to Rhumbas and Cha-Chas, leaving the Terpsichorians drooping and dripping.

One of the electrifying events of the evening featured the uncovering of the heretofore hidden musical talent of Iver (Bing) Freeman who lent his dulcet baritone voice in leading the group in singing the ancient Egyptian folksong "H-a-r-r-i-g-a-n" in honor of his Birthday that was celebrated with cake and candles. Another surprise was contributed by "Calypso George" Taylor who gave a mellow rendition of "Mother Macree" while he accompanied himself on the Bongo drums.

The program for the following year will be given momentum by the "Detroit Section 3rd Annual Regional Technical Conference" to be held on the week-end of September 27, 28 and 29 at St. Clair Inn. A refreshing program sparked by competent technical speakers has been planned, combined with recreational facilities of golf, swimming and fishing. A large enrollment is expected and those who plan to attend are urged to make their reservations promptly when announcements and cards are sent out at a later date.

Golf Tournament on 'Stag Day'

Forty-eight Divot Diggers from the Detroit Section teed off at the Grosse Isle Country Club with hopes of glory swelling in their breasts and thoughts of eagles, birdies and pars racing through their heads as they assaulted, or insulted, the well-trapped course during the Annual Spring Stag Day on June 4th.

As dusk descended over the landscape, the Club greenskeeper prostrated himself on the greensward and beat his fists into the ground as he surveyed the once well groomed fairways and velvety greens, that were now reminiscent of the battlefields on Saipan.

Most of the local lads played Civil War golf—"IN, in '61 and OUT in '64", but whatever was lacking in finesse was amply repaid in enthusiasm.

Later in the evening at the banquet tables, the non-golfers joined the Sod Busters and participated in acclaiming Tom Draper, Bill McMartin and Len Baranski as Detroit Section's threat to the throne occupied by Sammy Sneed.

The entertainment under the direction of Pat Luckino featured "Red" Jones, a former American League Baseball umpire who enlightened the group with amusing anecdotes of prominent baseball personalities.

The Fall Golf Stag Day will be held at St. Clair Country Club over the week end of September 27, 28 and 29 in conjunction with the "Detroit Section 3rd Annual Regional Technical Conference", and the holder of the low gross score of the two tournaments will be presented with the Stewart MacDonald Golf Trophy, emblematic of the Section's Championship.

Southern

Rigid PVC

R. E. Welch and E. O. Redwine

The regular monthly meeting was held on June 17 at the Engineers' and Architects' Building, Atlanta, Georgia. Mr. Thomas Hart, President, presided and Mr. Jones Sipe, Program Chairman, presented as the evening's speaker—Mr. Jean Malone, B. F. Goodrich Chemical Company, who addressed the group on the topic of Rigid Polyvinyl Chloride.

Mr. Malone underlined the extremely rapid growth of rigid PVC in this country since 1950 and pointed out that the unique combination of physical and chemical properties obtainable in rigid PVC would assure the continuation and increase this growth.

Rigid PVC is of three types: (1) A copolymer type, used in records, playing cards, advertising displays and the like; (2) Type I, a normal impact, unplasticized PVC; (3) Type II, a light impact PVC modified during manufacture to obtain increased impact resistance. The slightly lower chemical and physical properties obtained in Type II as compared to Type I are not significant except in the most critical applications.

There is a significant difference in the fields of application between the two rigid PVC types and the copolymer. The copolymer predominates in the field of sheeting and post-formed variations, while the rigid PVC types are most used in heavier structural designs such as pipe, fittings, valves, and specialized extruded shapes like moldings, window and door frame elements, and the like.

Mr. Malone pointed out that commercial standards for both rigid sheet and pipe have been established by S.P.I. and that the National Sanitation Foundation has approved rigid PVC pipe for use in potable water systems. The Department of Agriculture has approved Geon 8750 for use in meat plants for brine and other pipe lines, so acceptance by official and scientific bodies is becoming widespread.

By means of slides Mr. Malone illustrated a number of recent developments in the extrusion of rigid PVC as well as picturing a number of applications. These applications included a salt water disposal line in the oil fields, irrigation of an avocado orchid and use as electrical conduit and piping in the chemical industry.

Mr. Malone's talk was well received, as evidenced by a very active question session.

This meeting signaled the start of the summer recess period. Regular meetings will be resumed with the September meeting which is scheduled for September 16, 1957.

Flow Behavior vs. Melt Fracture . . .

Comment by Westover and Maxwell

(Discussion continued from page 36)

"Careful reading of this paper will reveal that we have not contradicted the results of other workers relative to the conditions under which melt fracture occurs, since we have not found melt fracture to occur in our experiments. It would be unwise to deny the existence of more than one mechanism for extrudate roughness on the basis of a single or even several investigations. The results of this study were based upon observations on one material at one L/D ratio in the range of pressures and temperatures representative of technological practice. Within this range of parameters, our data are consonant with the Reynolds turbulence criterion, and not at all with structural turbulence (cf. Fig. 9). The citing of other workers in the field, and their differing conclusions, is of course necessary and customary in a paper of this kind.

"In this paper and in subsequent work the criterion for extrudate roughness is the very first sign of surface defects, which is generally coincident with the break in the shear rate-shear stress curve. Having greater confidence in the accuracy and number of our data than in the visual observations of the inception of roughness, we believe the plotted data are most essential. For reasons of accuracy in locating this critical flow rate a large amount of carefully obtained data are necessary. To date we have not found a publication by other investigators that is similar enough in scope, method and details to check our results, to comment upon, or to speculate as to the reasons for the apparent differing results referred to by Dr. Tordella.

"It is our hope that other workers in the field will keep in mind the possibility of the occurrence of the Reynolds turbulence phenomenon, in order that the conditions in which it, in contrast to the phenomenon reported by others, may be defined."

R. F. Westover and Bryce Maxwell

University Instruction . . .

(Continued from page 53)

These surveys indicated that over 50 per cent of the engineering schools are offering one or more elective engineering courses in this field. With the exception of fractional parts of courses devoted to chemical technology, or non-metallic materials of construction, all such offerings are on an elective basis. Thus, the number of students enrolled in such courses would depend upon student choice and thus the number of graduates receiving some training in polymeric materials depends on student interest. Any marked expansion of training in the field of polymeric materials will probably depend on arousing more interest among undergraduate students. In the 1951 and 1953 surveys, many replies indicated a lack of such student interest. Very often comments such as "Not offered in the last three years" or "Offered only on demand", were included. The replies to the 1956 questionnaire showed some indication of increasing student interest. No specific questions were asked about the number of students enrolled in various courses but apparently there was an increase. It should be remembered that these surveys dealt with offerings in the regular university sessions and not with extra-mural or night school courses. Undoubtedly there is a very definite demand for additional part-time work in this area for men employed full time.

Approximately one-fourth of the schools replying indicated that laboratory courses involving polymeric materials were being given. With a few exceptions, these laboratory courses are given by chemistry departments and deal principally with polymerization reactions. As mentioned above, very few facilities are available possessing laboratory fabricating and processing equipment.

Although these surveys provide a rather pessimistic view of the amount of instruction offered on polymeric materials, there are indications of a growing interest in these fields on the part of instructional staffs. An increasing number of younger instructors have had industrial experience in these fields and are working more and more such subject matter into existing broader courses. In addition, the amount of research being carried out is not indicated. Many institutions are carrying out a considerable amount of research on polymeric materials that is not done in regularly scheduled courses.

Southern California

Plastics Phonograph Records

John A. Stahmann

An overflow audience of 144 members and guests bulged Scully's Restaurant on Thursday, June 6th. The occasion was a joint meeting between the Southern California Section of the S.P.E. and the Record Pressers Association. High interest in high fidelity systems helped make this the fourth time this year that attendance has been over one-hundred.

The evenings program was presented by Messrs. O. G. Maxson and P. C. Woodland, both from the Plastics Technical Service of Dow Chemical Company. Background information was based on work for a paper presented at the last National Technical Conference.

Since World War II, when sources of shellac were cut off, use of synthetic resins for record materials has become prevalent. Polyvinyl chloride and improved styrene copolymers have been used to reproduce sound with high fidelity. Adequate performance and wear characteristics of these materials have been demonstrated by auditory, visual and electronic means. A wear life of 100 plays is considered satisfactory.

Visual tests include flatness, freedom from contamination and blisters, and completeness of fill. Good grooving can be shown by edge view under the microscope.

Excellent audio equipment is necessary to properly determine how the record sounds. Surface noise and distortion are checked. Wear life can be roughly estimated by comparing the sound from a new record to that having many plays.

For laboratory selection of molding compounds and other experimental purposes, auditory and visual examination are not accurate enough, and electronic equipment is employed. In this case harmonic distortion (multiples of the fundamental frequency) and intermodulation distortion (interjection of new frequencies) are used as criteria. Of these, intermodular distortion checks are the most sensitive. By molding a special test record, wear characteristics, noise levels, and optimum molding conditions may be obtained.

A tape recording demonstrating the differences in materials and molding materials was included in the program.

book reviews

ASTM Standards on Plastics

This compilation of ASTM Standards on Plastics contains 40 specifications, 93 methods of tests, 19 recommended practices and 5 definitions. Of these, 34 are new or revised. Most of the standards contained were prepared under the jurisdiction of Committee D-20 on Plastics. However, certain of the standards were in the field of electrical insulation and are the work of Committee D-9.

Among the topics covered are the mechanical, thermal, optical and performance properties of plastics. In addition standards for molding compounds, standard shapes and molds are included. Analytical methods, compounding and electrical tests specifications for plastics are also to be found in this compilation. The Appendix contains two proposed standards presented for information.

This volume should be of interest to plastics engineers, chemists and electrical engineers concerned with insulating problems. Copies of this book may be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. at $6.00 each.

Symposium on Tension Testing of Non-Metallic Materials

This Symposium discusses aspects of one of the simplest tests which can be made on any material, a measure of the tensile pull required to break it. Perhaps it is in part this simplicity, both of concept and of execution, which has made tensile properties a common denominator in testing of material, especially in the field of metals.

Among the non-metallic materials, however, there is such a diversity of structure and properties, that there has evolved a variety of methods for measurement of tensile properties. New materials have been developed for which older techniques are inadequate, new technical tools have been applied to the problem, new understanding of the structure of materials has brought a more meaningful interpretation of results and each of these factors has contributed to the terminology and nomenclature of tension testing.

The objectives of the Symposium were to give: (1) An accurate summary of present practices in fields where tension testing is most widely used; (2) A critical appraisal of their merits and deficiences; (3) An opportunity to compare techniques and terminology among the various fields; and (4) A guide to future development and standardization.

Included in the Symposium are five papers on the testing of plastics, adhesives, rubber, wood and paper. The Symposium was sponsored by ASTM Committee E-1 on Methods of Tests. Copies of this book may be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., at $2.00 each.

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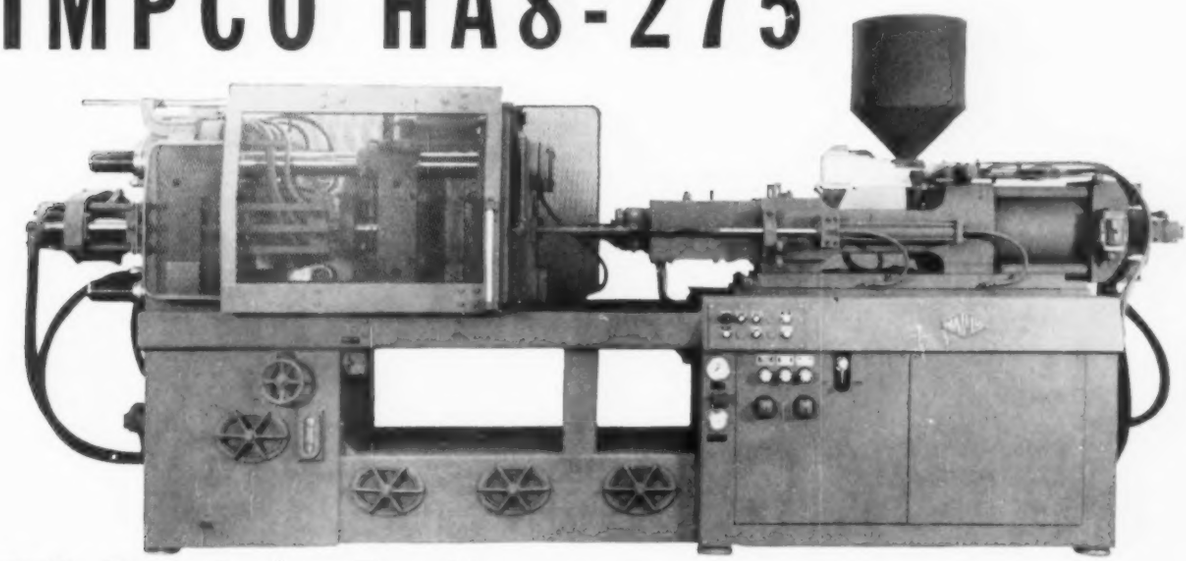

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Book Reviews . . . (from preceding page)

TECHNICAL DATA ON PLASTICS, Edited by the Manufacturing Chemists Association, Washington, D.C., (1957, 224 pp. $3.25)

This is a compilation of data obtained by using ASTM test methods. They include compression ratio, tabletting, specific gravity, haze, luminous transmittance, refraction, thermal data, flammability, moisture absorption, shrinkage, effect of light, chemical resistance, dielectric properties, strain, stress, permanence and many others.

HANDBOOK ON MATERIAL TRADE NAMES, SUPPLEMENT 1 TO 1953 EDITION, by O. T. Zimmerman and Irvin Lavine (Industrial Research Service, Inc., Dover, N. H., 1956, 383 pp., $12.50)

"This is more than just a book—it is a service to you." This statement, made by the publishers, is not an exaggeration, as this handbook contains more information than many chemical encyclopedias and dictionaries, as far as trade names are concerned. The fact that trade names are in these times the essence of industrial chemistry emphasizes the value of such a book.

The nomenclature is divided very wisely into two parts, one listing trade names beginning with letters, the other one trade names beginning with numbers. Even manufacturers' catalogues are not always as easy to read. The classification section lists manufacturers of materials according to their nature, properties and uses. The Directory section gives in alphabetical order the names and addresses of the manufacturers of the materials listed in the first parts of the manual.

Users of chemicals will find this compendium absolutely indispensible.

Louis C. Barail

Patents, Trademarks . . .

(Continued from page 41)

at this time. The examiner will report his holdings to counsel in a so-called "Action", to which response must be made within a six-month period, unless some shorter time is set by the Patent Office. In responding, counsel will amend or argue the claims as may be best in the light of the prior patents or publications cited by the examiner. When this reaches the Patent Office it must again await its turn and the examiner will then consider the new issues and usually make a second search that may give rise to further rejections, to which counsel must respond as before. Usually a distinct issue has been reached by the examiner's third action and if the presented claims are not all allowable, as evidenced by issuance of a Notice of Allowance, those remaining rejected must be cancelled or appealed. Within six months of the eventual Notice of Allowance, indicating that all the existing claims are allowed, a final government fee, usually $30.00, is payable. The patent issues several weeks thereafter and printed copies are available from the Patent Office at a cost of twenty-five cents each. Before such issuance, the patent application remains secret.

With patents, as with other complex subjects, there are often exceptions to any statement of general principles. As to these exceptions, reference must be made to texts or to patent counsel as they are beyond the scope of the present discussion which, at best, can give no more than a general understanding of the points discussed. Nevertheless the elementary principles of copyrights, trademarks, and design patents and utility patents are often confusing to engineers and it is hoped this discussion of some of the fundamentals may be helpful. ★ ★

Golden Gate

William Hill

James O. Turner, materials engineer, University of California, Radiation Laboratory, Berkeley, was the speaker at the May 23 meeting of the Golden Gate Section of the Society of Plastics Engineers held at Pland's Restaurant, Oakland. Turner discussed the role of plastics in nuclear research. Plastics are sometimes used, said Turner when non-metallics are required for electric isolation, radiation detection, and radiation containment. These materials must operate under rigorous conditions such as: high vacuums (5×10^{6} mm), high voltages (up to 20,000 volts per inch), extreme mechanical forces, contact with heavy copper conductors, extreme temperatures (low as −424°F. and as high as +450°F.), said Turner.

He outlined the present uses of plastic in nuclear research as follows: Styrene is polymerized under special conditions to provide scintillator blocks for large scale detection of radiations. A scintillator emits light under the influence of radiation and the measured light is a measure of radiation; Acrylics are used to "pipe" light for the scintillator counter to measurement devices; Epoxy resins are used to encase coils used in high voltage applications, especially where high vacuums and high mechanical strength is required. Glass cloth is used for additional strength in some cases.

The announcement was made at the meeting that the National Council may meet in Los Angeles in 1959.

Chicago Section

Joseph J. Schmidt

Eighty-nine SPE members and guests braved Chicago's heaviest rainfall since 1885 to attend the Chicago Section golf outing on July 12th at the Hasca Country Club. In spite of the weather approximately 40 golfers managed to complete their 18 hole rounds.

The Chicago Section will continue to meet on the second Monday of each month for technical programs, opening the 1957-58 season on Monday, September 9th, at the Headquarters Western Society of Engineers. Ken Rouzer, Chicago Section President, and Charles E. Rank, Program Chairman, predict that Chicago members can look forward to an outstanding group of technical programs on diversified subjects related to plastics, starting with the Fall series.

Southeastern Ohio Section

H. R. King

The April meeting of the Southeastern Ohio section was called to order by Don Frazzoni.

It was announced that Mr. F. Burkhart, our treasurer of the local chapter would be leaving us in the near future and it was necessary to elect a new treasurer. Mr. Ray Baker of Fabri-Form was elected to replace Mr. Burkhart, with Mr. H. R. King to take over as secretary.

The May meeting was held at the Cambridge Country Club as Ladies Night. Door prizes were given in addition to a favor to every one attending.

To start the fall season the program for September will be very interesting if everything pans out. A tour of R.C.A. is being thought of for that meeting.

frankly SPE aking

We can Learn "How" Faster if We Know "Why" Sooner!!!

When Professor L. E. Stout of Washington University spoke at the SPE Conference in St. Louis, he said that the difference between the training of Engineers and that of Technicians, is merely that the Engineers learned "why" rather than just "how"!! It seems to me that anyone can learn the "how" of an operation much more rapidly if he knows "why" certain things must be done.

During World War II, I had occasion to instruct several women operators in the very delicate task of finishing plastic parts to Aircraft Standards. I recall one particular job in which we were trying to finish a 1/16th inch radius tangent to a flat surface and to the inside diameter of the part. Many hours were spent with several different operators trying to instruct them in the proper finishing procedure. The difficulty in finishing was that each operator would leave a small break in the surface at the point where the radius was supposed to come tangent. The particular parts in question were assembled with a very thin rubber diaphragm which stretched and contracted across the radius. Any sharp break in the surface would cause failure of the diaphragm.

It was only after showing these operators an assembly of the unit, and "why" it was necessary to have a tangent radius, that we were able to get the molded parts properly finished. After showing the "why" of the operation, we had very little trouble with the "how" of the operation.

One common failing in the transmission of information is to issue orders that say, in effect, "Do it this way because I say so!!". A little care in explaining "why" will greatly reduce the time required to learn "how".

Yours for better living with Plastics

Wayne I. Pribble

Technical Conferences

See Announcements

on page 56

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Here is a single-stage, high-impact molding compound that opens new territory to the profitable application of phenolics.

To illustrate: Chrysler Corporation engineers saved about two-thirds the cost of the former metal part when they pioneered in developing this oil pump gear of precision-molded "16771."

What's more, the molded gear outwears the former unit by practically three to one in withstanding the heat and friction generated in automotive transmissions. The gear of molded Durez shows no performance-affecting wear after 200,000 miles, while the metal part showed equal wear at only 70,000 miles. Noise reduction is another major achievement.

Durez "16771" is particularly designed for resistance to hot oil immersion and acid aqueous conditions. It has excellent dimensional stability, a high modulus of elasticity, and good electrical properties. Durez "16771" is suitable for molding by standard compression methods and produces parts having dependably uniform characteristics.

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Write to : Mr. Frank A. Martin, The Hoover Company, North Canton, Ohio.

Small aggressive Sales Organization has opening for Salesman with some injection and compression experience, to travel Michigan, Ohio and Indiana selling equipment to molders. Salary and expenses. Selling experience not essential. All replies held strictly confidential. Reply to Box X-8, SPE, 34 E. Putnam Ave., Greenwich, Conn.

Plant Manager

Thoroughly familiar with phases of Injection Molding; with background of engineering inventory and cost control, and quoting. Have been in Plastics for 16 years with experience in appliance and automotive production. Will forward resume of work experience and will arrange for personal interview. Presently General Manager of Injection Molding plant in Midwest. Owners of plant know about this advertisement. Reply to Box 2157 SPE Journal, 34 E. Putnam Avenue, Greenwich, Conn.

Plastic Pipe Fittings You Can Trust...

ANNOUNCEMENT

E & A Sales, Inc., manufacturer of quality plastic pipe fittings, has been purchased by the Seamless Rubber Company of New Haven, Connecticut.

Output has been increased by the addition of two new 28-ounce molding machine units at a cost of $50,000 each. Immediate plans include new dies in all sizes from 3/8" to 6", to make the line the industry's largest and most complete.

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Manufacturer's Representative

Nylon-Industrial Injection Molding

Nylon molder in Midwest desires representation in major industrial areas outside of Chicago. This molder specializes in precision applications and has a record of experience with many different parts; having produced several hundred million nylon parts in past few years. Reply Box 2357, SPE Journal, 34 E. Putnam Ave., Greenwich, Conn.

Chemist and Salesmen

Young research and development chemist who knows resins, latex and chemicals for textile finishes,—will have own private laboratory—Location, city in South.

Also wanted: 2 sales men to sell chemicals for textile finishes—resins and latex—one N.E., one in Atlanta. Box No. 2257, SPE Journal, 34 E. Putnam Ave., Greenwich, Conn.

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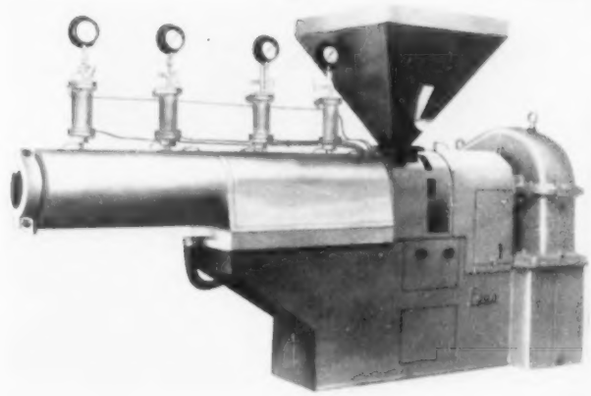
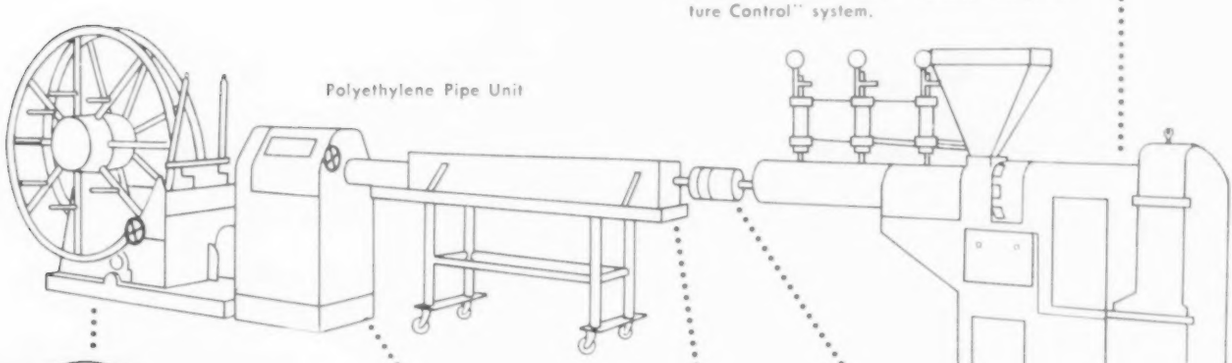
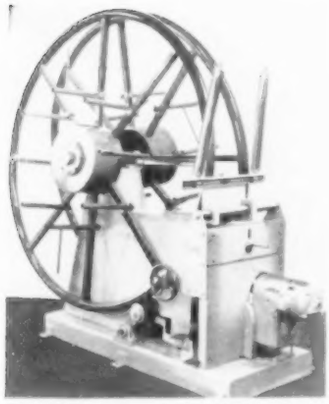
Complete extrusion installations or accessories available for pipe, film, sheet, shapes.



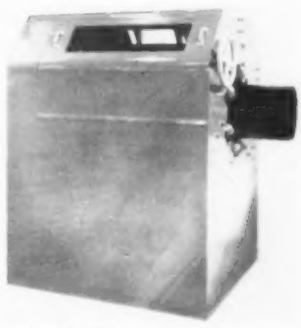
*EGAN EXTRUDERS: pre-set the temperature; "Willert Temperature Control" system takes over, providing completely automatic instrumentation.
*also available without "Willert Temperature Control" system.



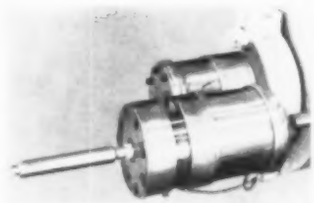
Polyethylene Pipe Unit



COILERS: dual reel type, with or without automatic level wind.



TAKE-OFFS: roller or multiple belt types in diameters of ½"—6" or 3"—14".



DIES: offset or straight-out, with or without extended mandrels.

COOLING TANKS: with vertical and horizontal adjustments.

FRANK W. *Egan* & COMPANY

SOMERVILLE, NEW JERSEY

Manufacturers of plastics processing equipment

Cable Address: EGANCO — SOMERVILLE NJER

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Capping a sustained 35-year program of research and development in high polymers, Hercules has brought on stream a 30-million pound plant to produce the new ethylene polymer Hi-fax. An exciting new material, Hi-fax is made by an exclusive Hercules low-pressure process employing Ziegler-type catalysts. Hi-fax has an individuality, a combination of properties all its own, that makes it the leader in polyolefins today.

Hercules has followed Ziegler chemistry since 1950, and had its chemists studying in Ziegler's laboratory in 1954. In 1955, Hercules imported the first commercial high-density polyethylene, and has since maintained an ever-widening program of market development.

Hi-fax, therefore, represents a combination of basic research, early production experience, and final translation into the highest standards of American chemical manufacture. It opens new horizons for the plastics industry, new opportunities for you.

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The new Hercules Hi-fax plant makes available for the first time in America a commercial plant producing proved polyethylene by the Ziegler catalysis. More than that, the plant incorporates all the "know-how" of Farbwerke Hoechst, AG. of Germany, the world's first commercial producer of high-density polyethylene, with whom Hercules has a working agreement for the continuing exchange of research and processing information.

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This means that Hi-fax comes to you completely proved and established not only in the laboratory but in applications that encompass the widest range in the plastics field.

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Cellulose Products Department

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